

Efficient Use of Energy, a Physicist's Perspective

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<http://www.energy.ca.gov/commission/commissioners/rosenfeld.html>

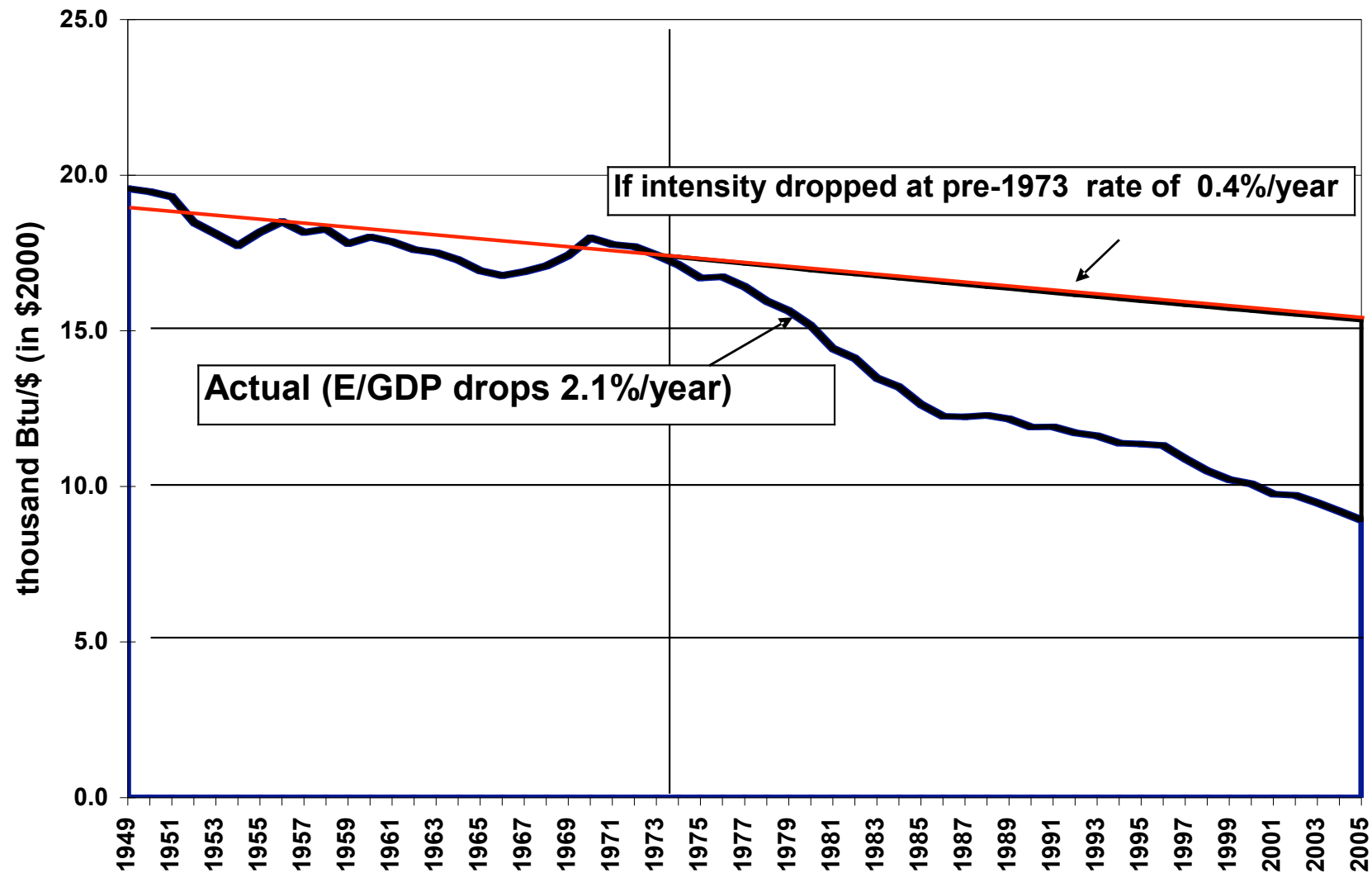
1949

Rosenfeld

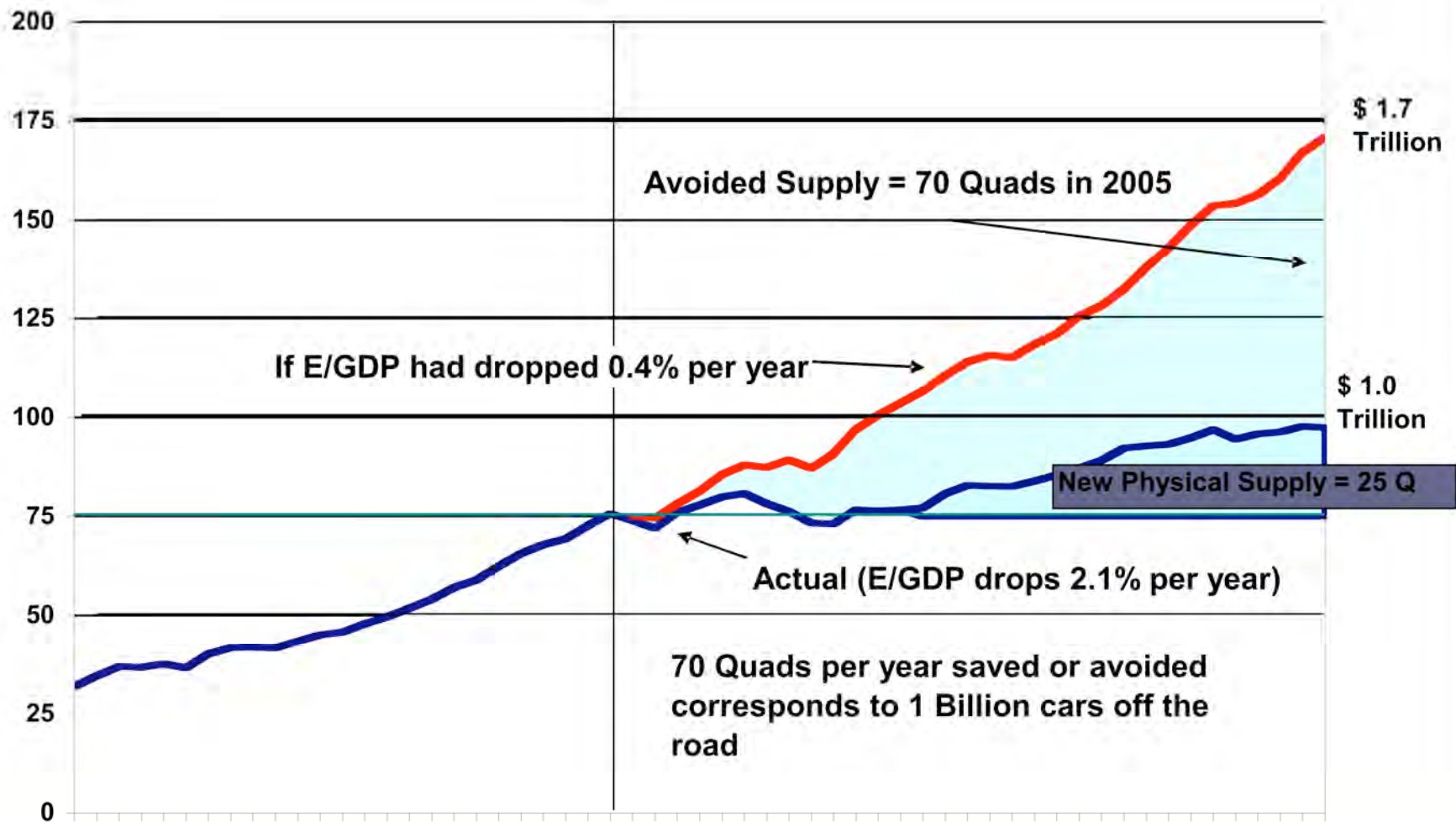
Nuclear Physics

A Course Given by **ENRICO FERMI**
at the University of Chicago. Notes Compiled by
Jay Orear, A. H. Rosenfeld, and R. A. Schluter

Energy Intensity in the United States 1949 - 2005



Energy Consumption in the United States 1949 - 2005



How Much of The Savings Come from Efficiency?

- ◆ Easiest to tease out is cars
 - In the early 1970s, only 14 miles per gallons
 - Now about 21 miles per gallon
 - If still at 14 mpg, we'd consume **75 billion gallons more** and pay **\$225 Billion more** at 2006 prices
 - But we still pay **\$450 Billion per year**
 - If California wins the “Schwarzenegger-Pavley” suit, and it is implemented nationwide, we'll save **another \$150 Billion per year**
- ◆ Commercial Aviation improvements save another **\$50 Billion per year**
- ◆ Appliances and Buildings are more complex
 - We must sort out true efficiency gains vs. structural changes (from smokestack to service economy).

How Much of The Savings Come from Efficiency (cont'd)?

- ◆ Some examples of estimated savings in 2006 based on 1974 efficiencies minus 2006 efficiencies

	Billion \$
Space Heating	40
Air Conditioning	30
Refrigerators	15
Fluorescent Tube Lamps	5
Compact Fluorescent Lamps	5
Total	95

- ◆ Beginning in 2007 in California, reduction of “vampire” or stand-by losses
 - This will save \$10 Billion when finally implemented, nation-wide
- ◆ Out of a total **\$700 Billion**, a crude summary is that 1/3 is structural, 1/3 is transportation, and 1/3 is buildings and industry.

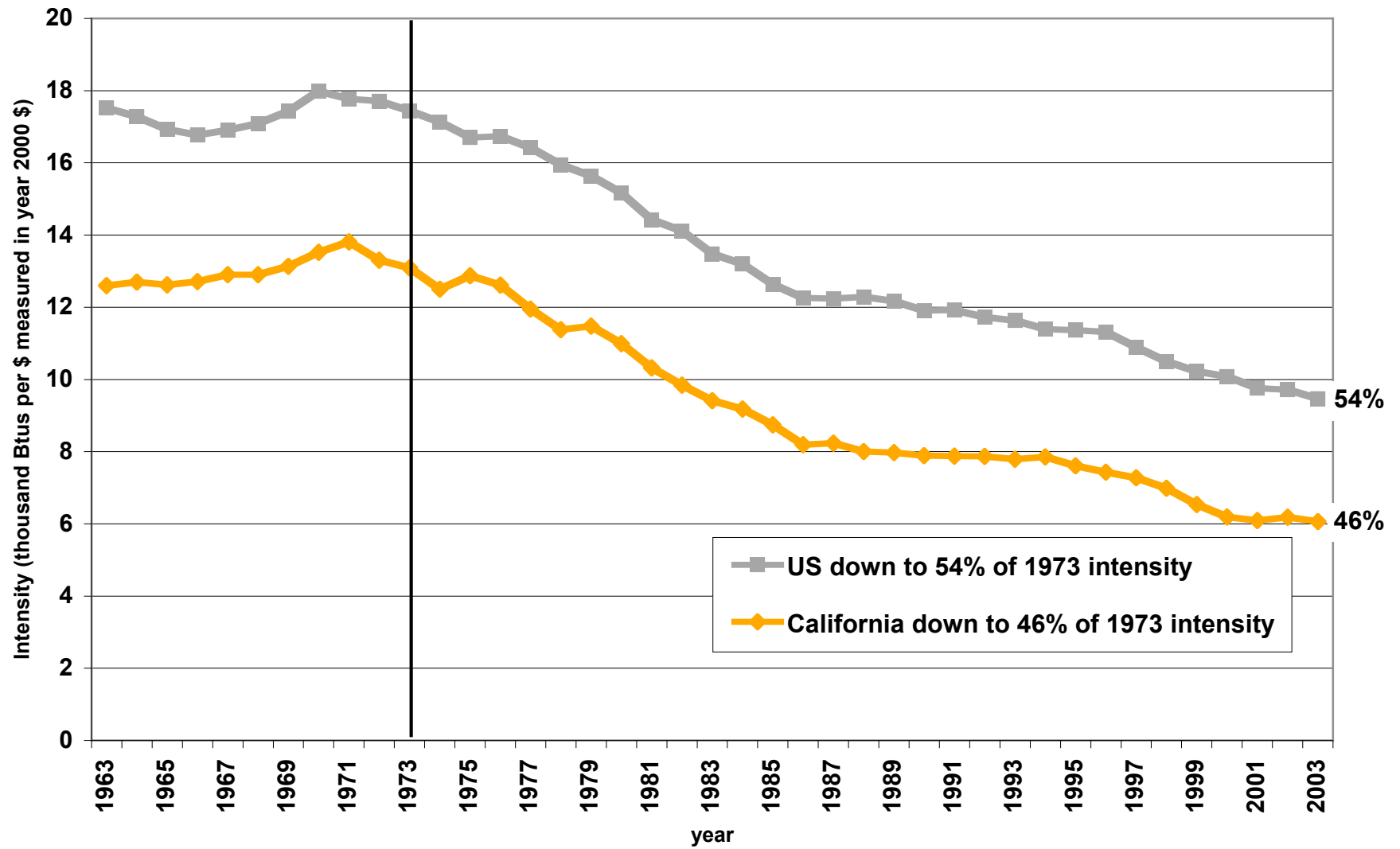
A supporting analysis on the topic of efficiency from Vice-President Dick Cheney

- ◆ “Had energy use kept pace with economic growth, the nation would have consumed 171 quadrillion British thermal units (Btus) last year instead of 99 quadrillion Btus”
- ◆ “About a third to a half of these savings resulted from shifts in the economy. The other half to two-thirds resulted from greater energy efficiency”

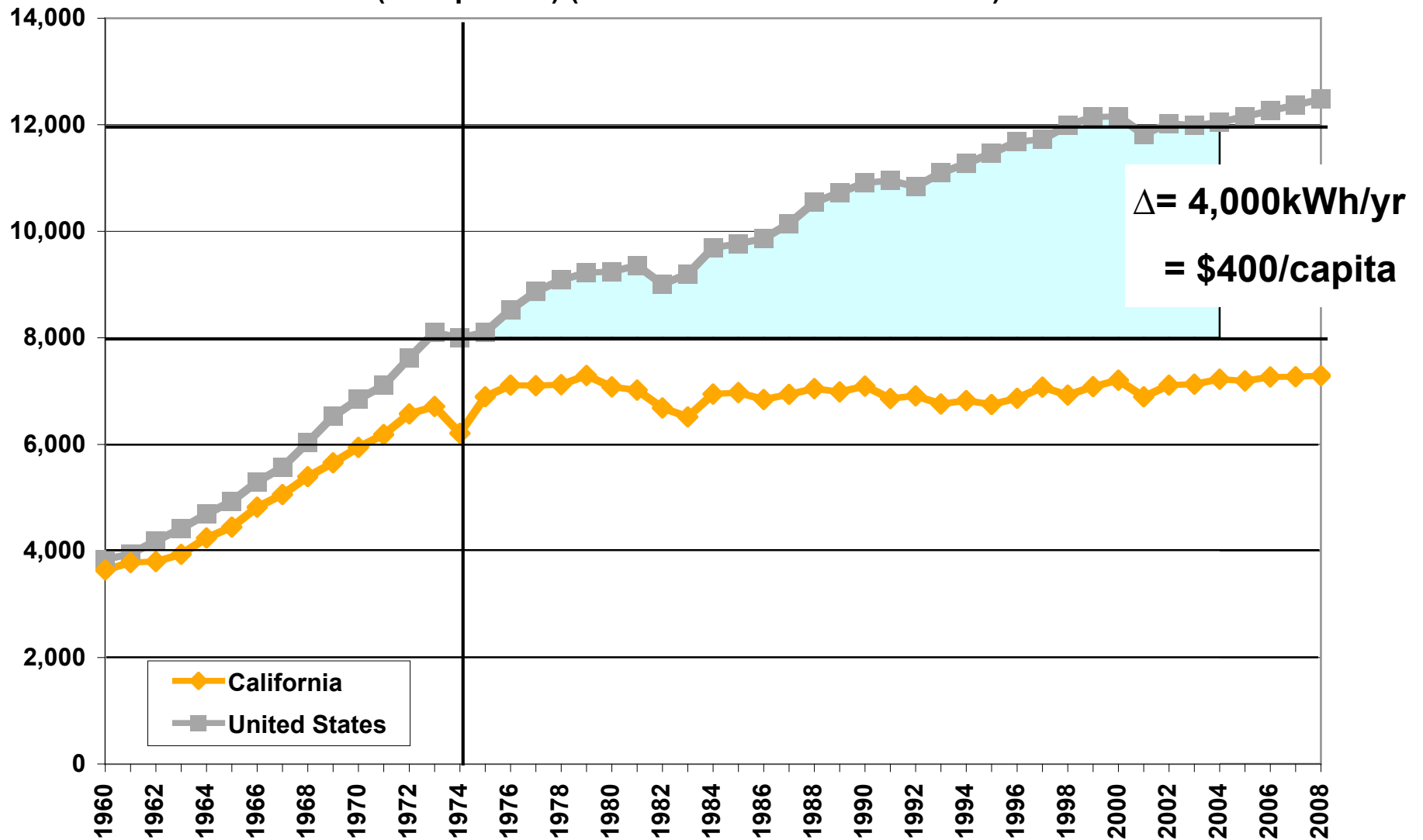
Source: National Energy Policy: Report of the National Energy Policy Development Group, Dick Cheney, et. al., page 1-4, May 2001

Cheney could have noted that 72 quads/year saved in the US alone, would fuel one Billion cars, compared to a world car count of only 600 Million

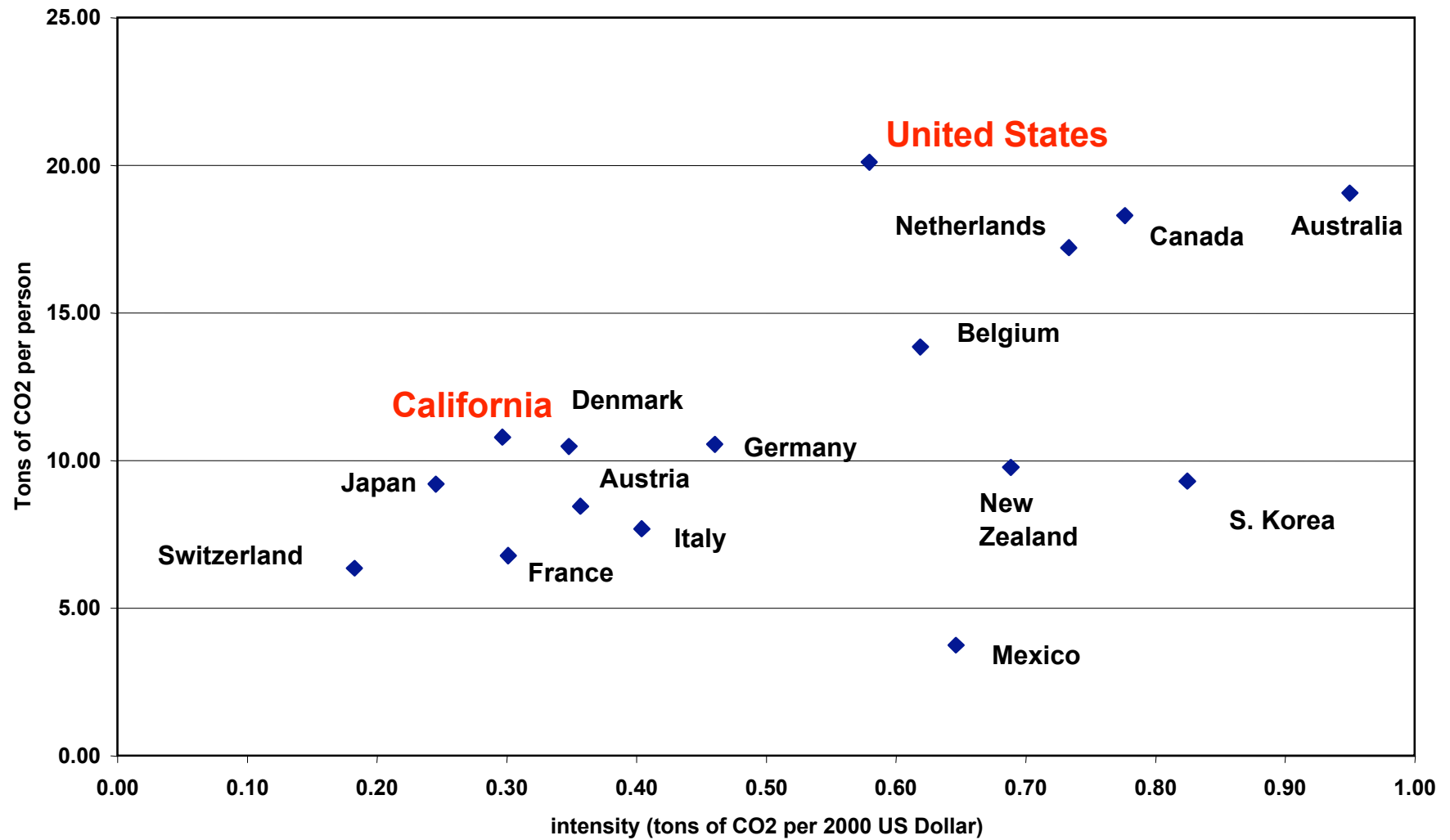
Energy Intensity -- California and the United States



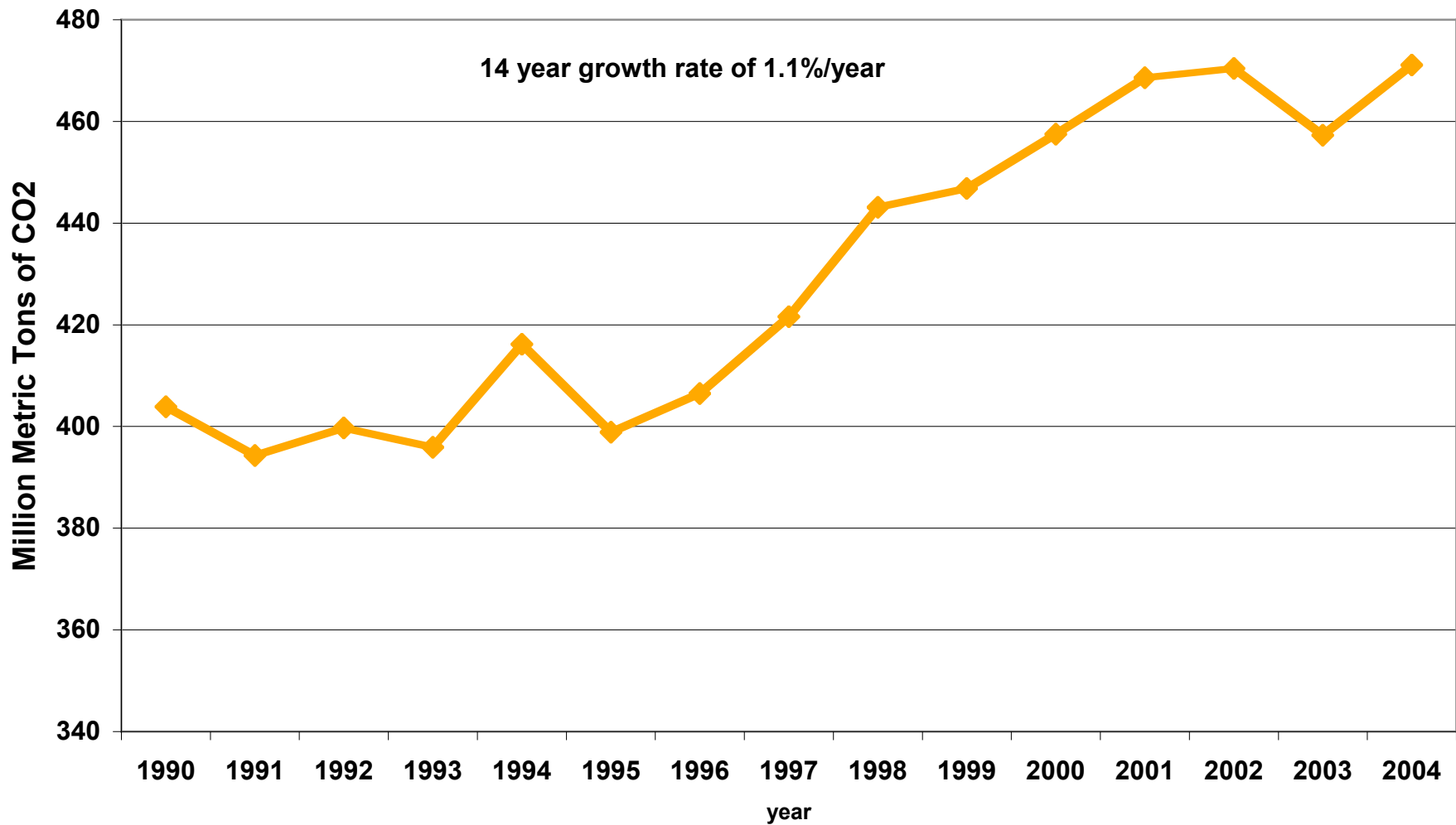
Per Capita Electricity Sales (not including self-generation)
(kWh/person) (2005 to 2008 are forecast data)



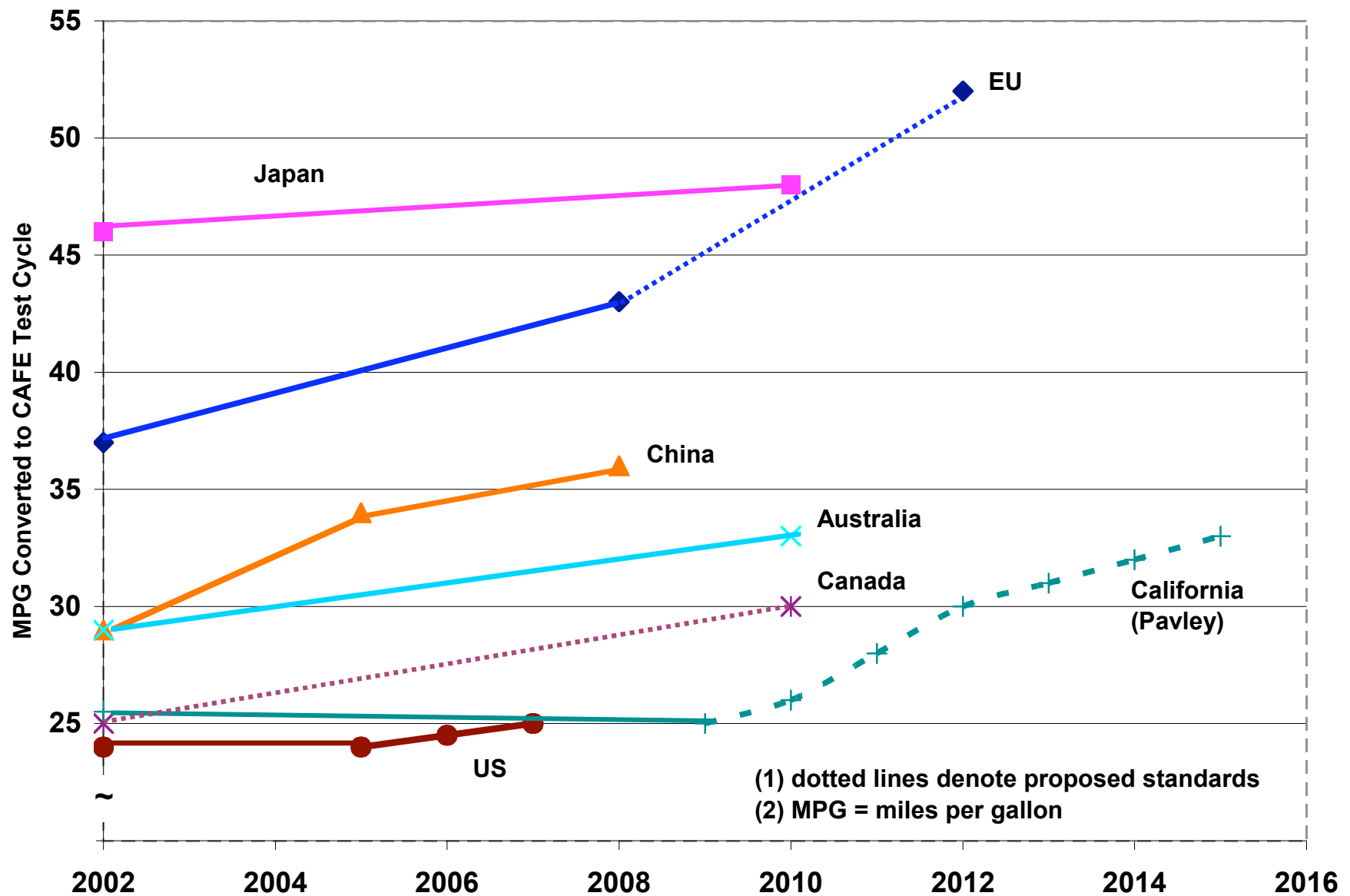
Carbon Dioxide Intensity and Per Capita CO2 Emissions -- 2001
(Fossil Fuel Combustion Only)



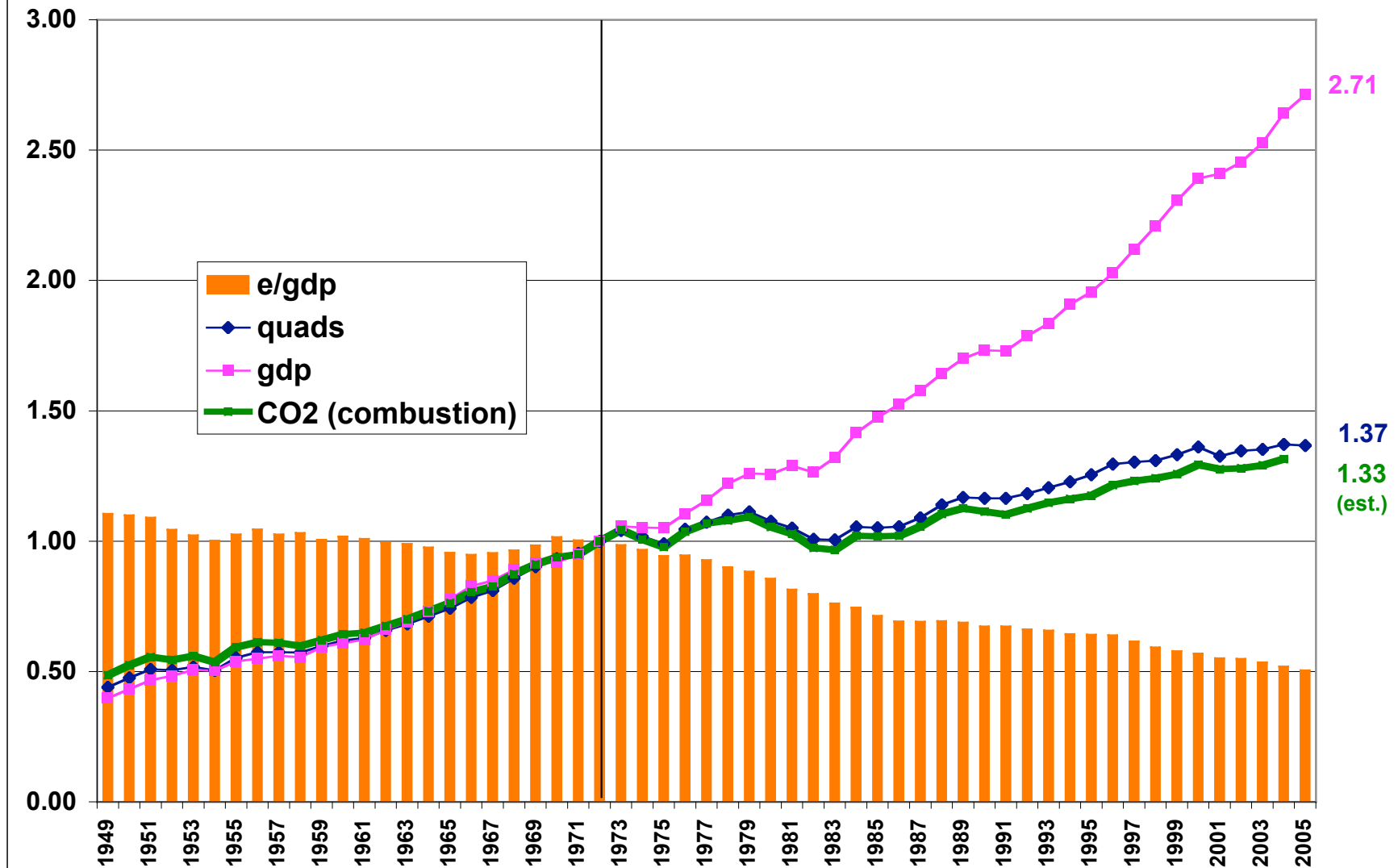
CO2 Emissions in California Including Electricity Imports 1990 - 2004



Comparison of Fuel Economy – Passenger Vehicles

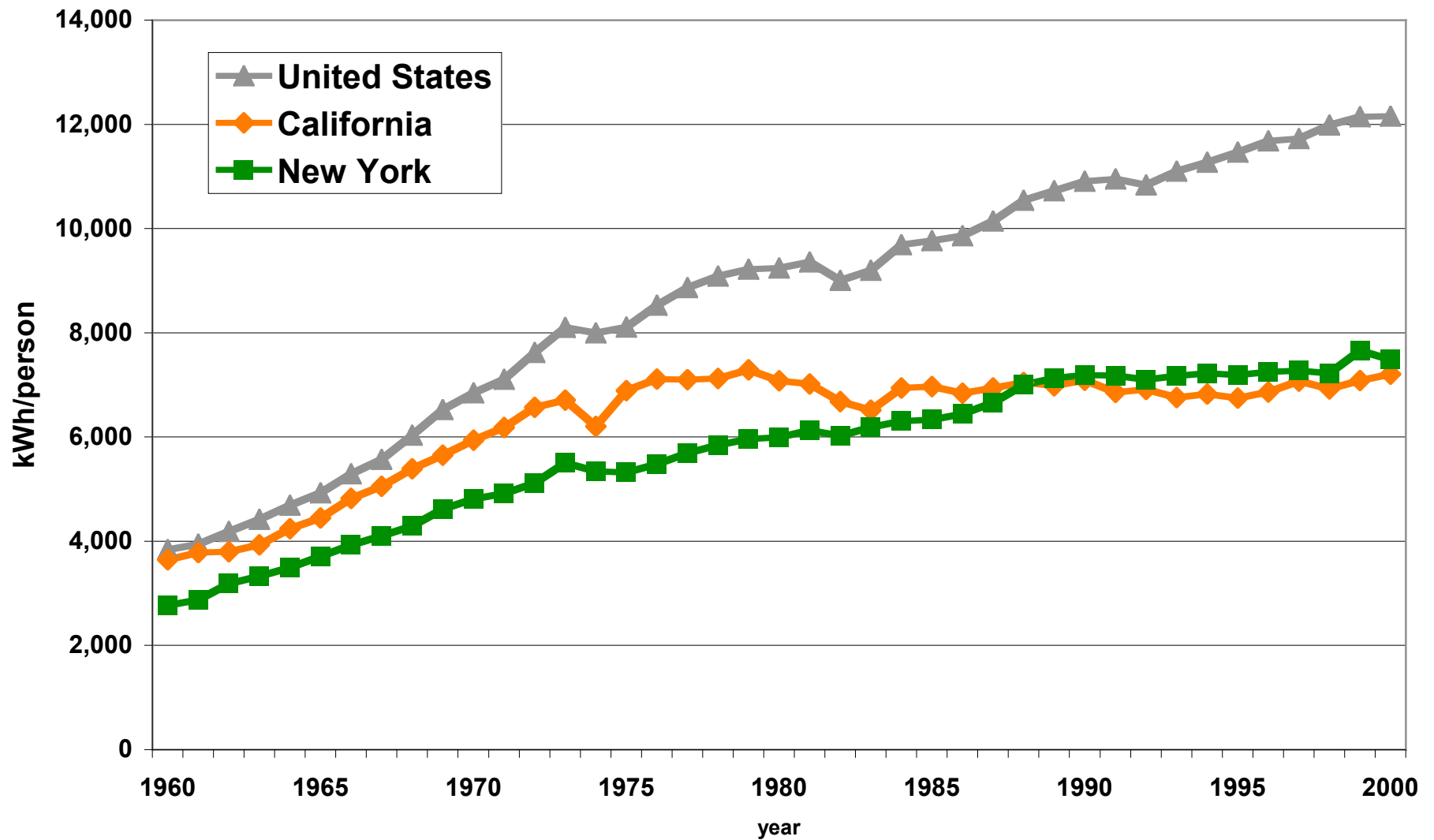


Index (1972 = 1.00) of U.S. Energy Use, GDP, Energy Intensity and Carbon Dioxide
last 10-year CO2 growth = 1.3% per year

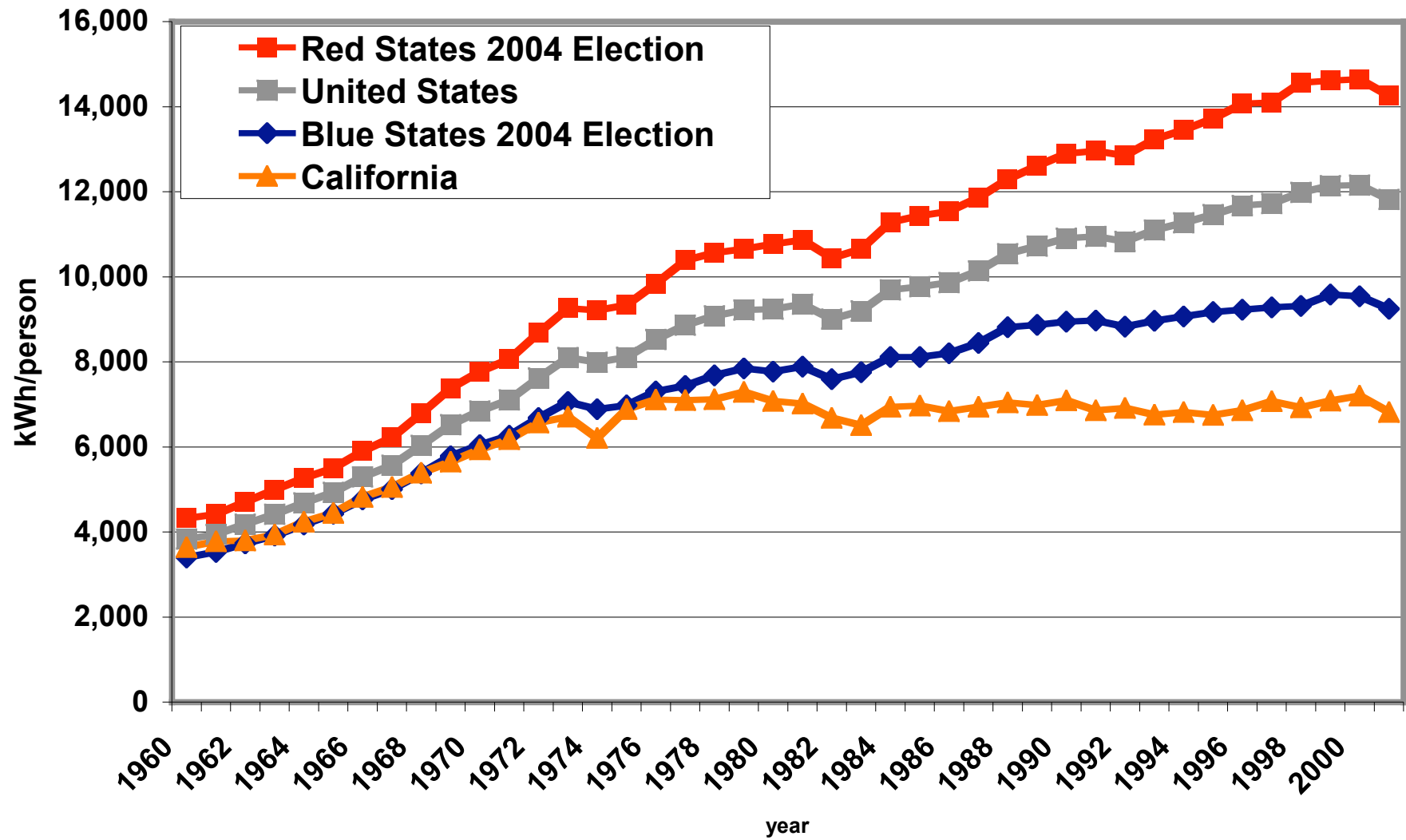


Per Capita Electricity Consumption

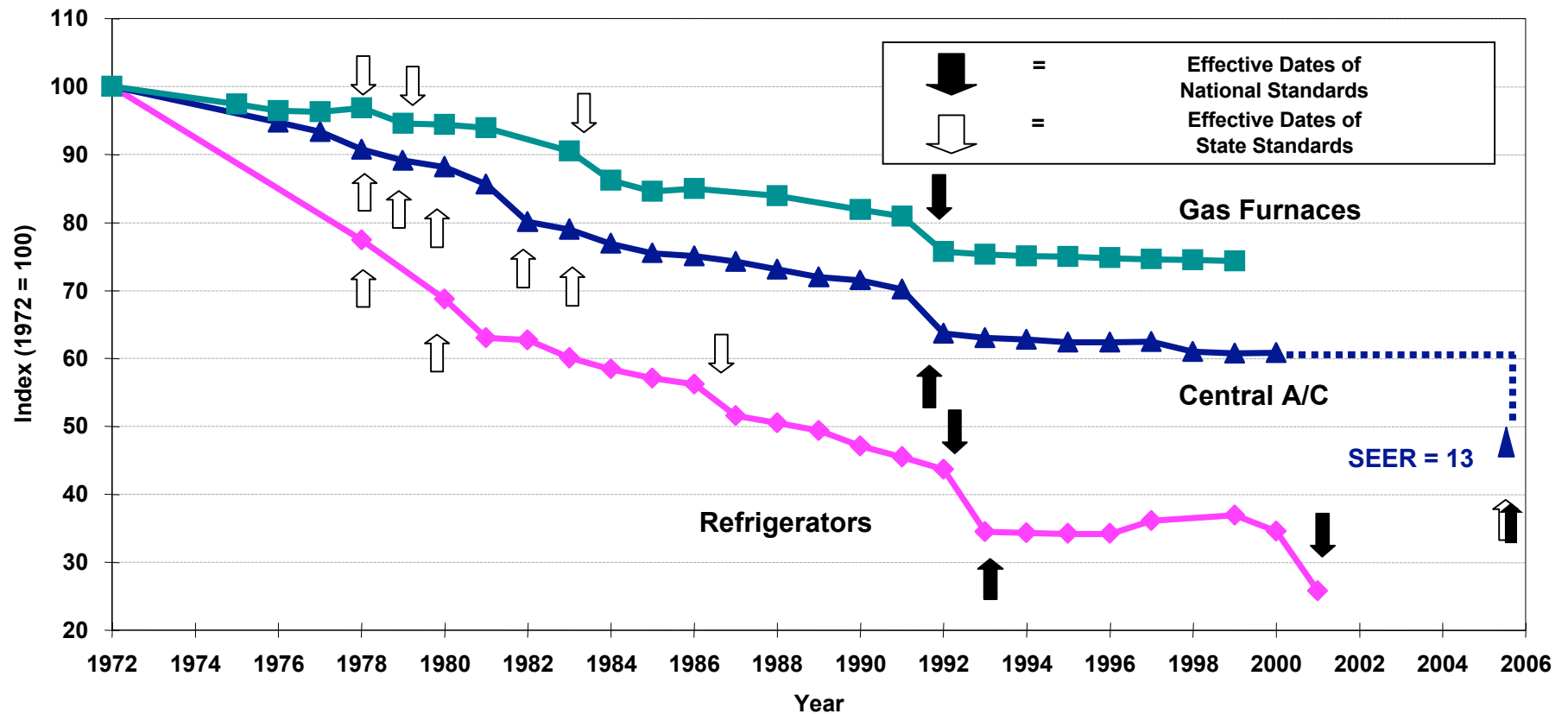
Source: http://www.eia.doe.gov/emeu/states/sep_use/total/csv/use_csv



Per Capita Electricity Consumption

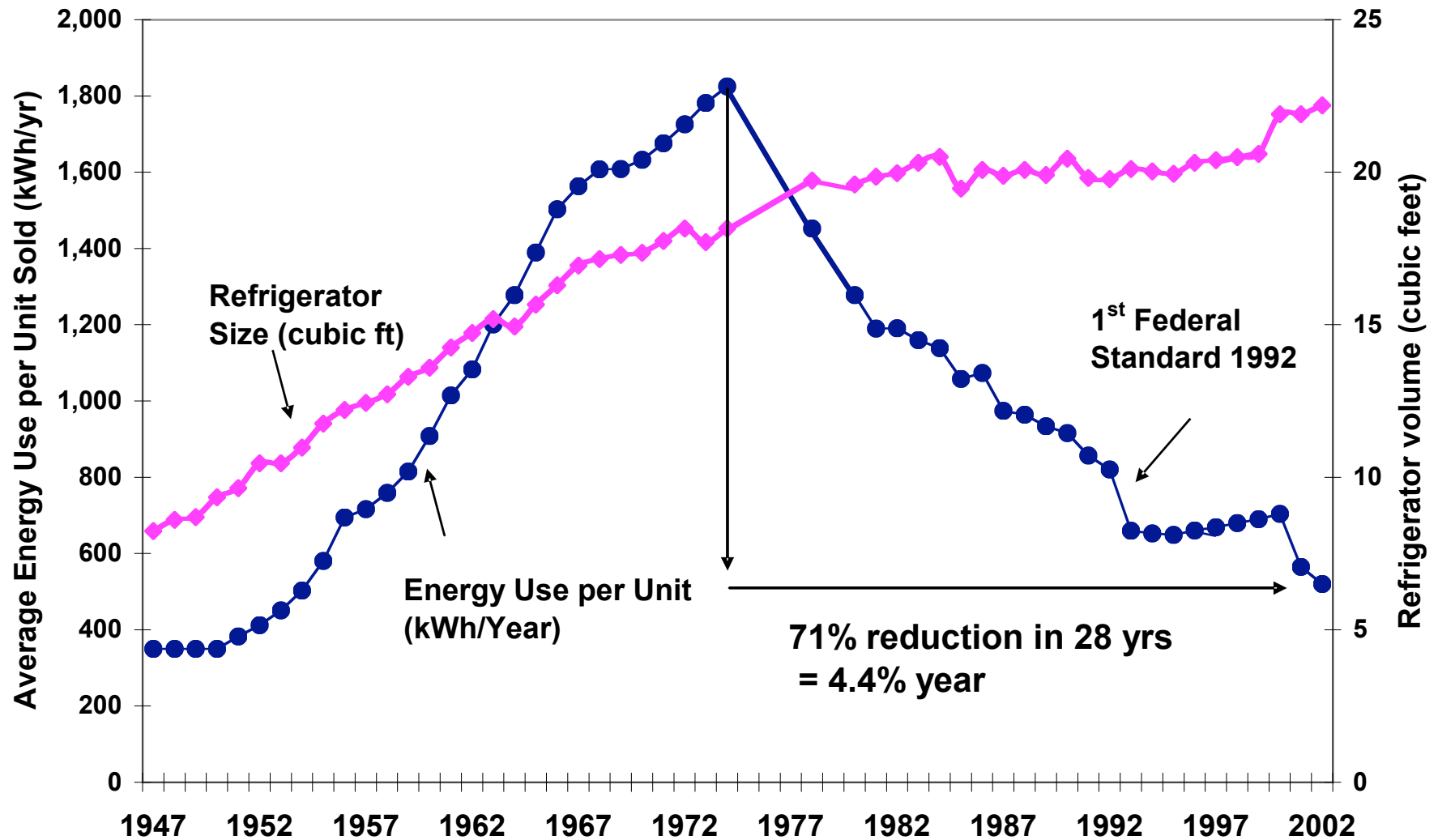


Impact of Standards on Efficiency of 3 Appliances

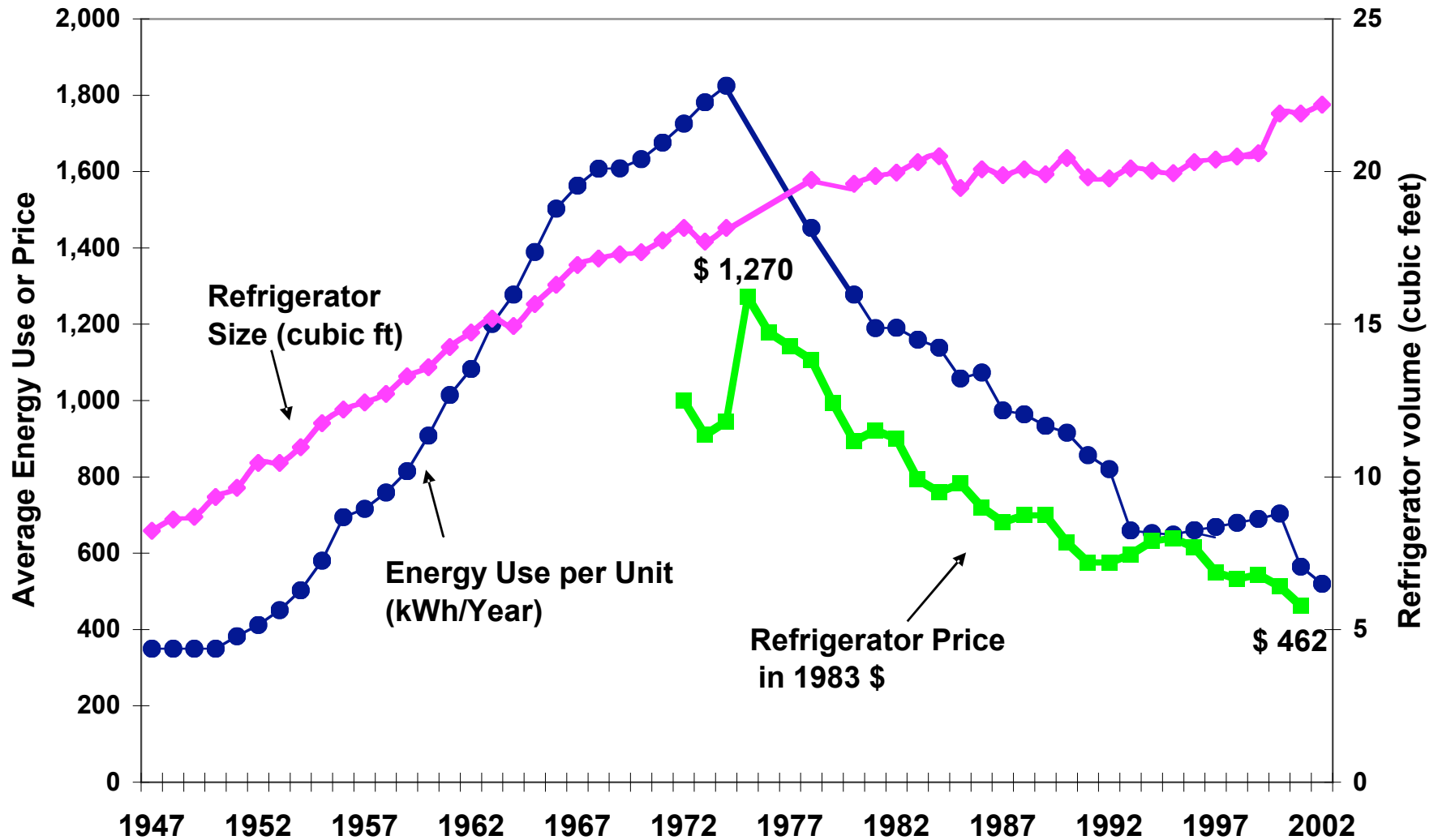


Source: S. Nadel, ACEEE,
in ECEEE 2003 Summer Study, www.eceee.org

New United States Refrigerator Use v. Time

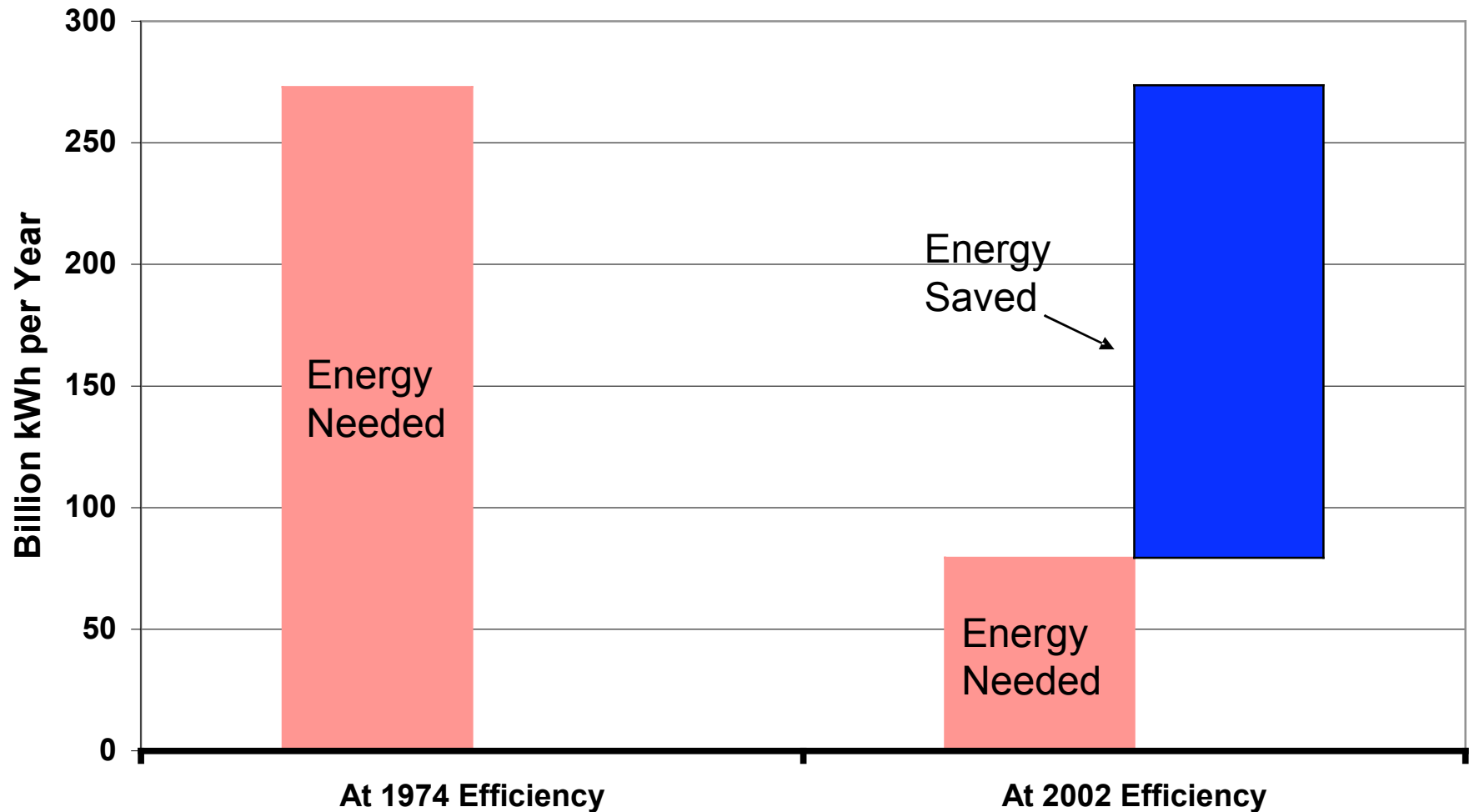


New United States Refrigerator Use v. Time and Retail Prices

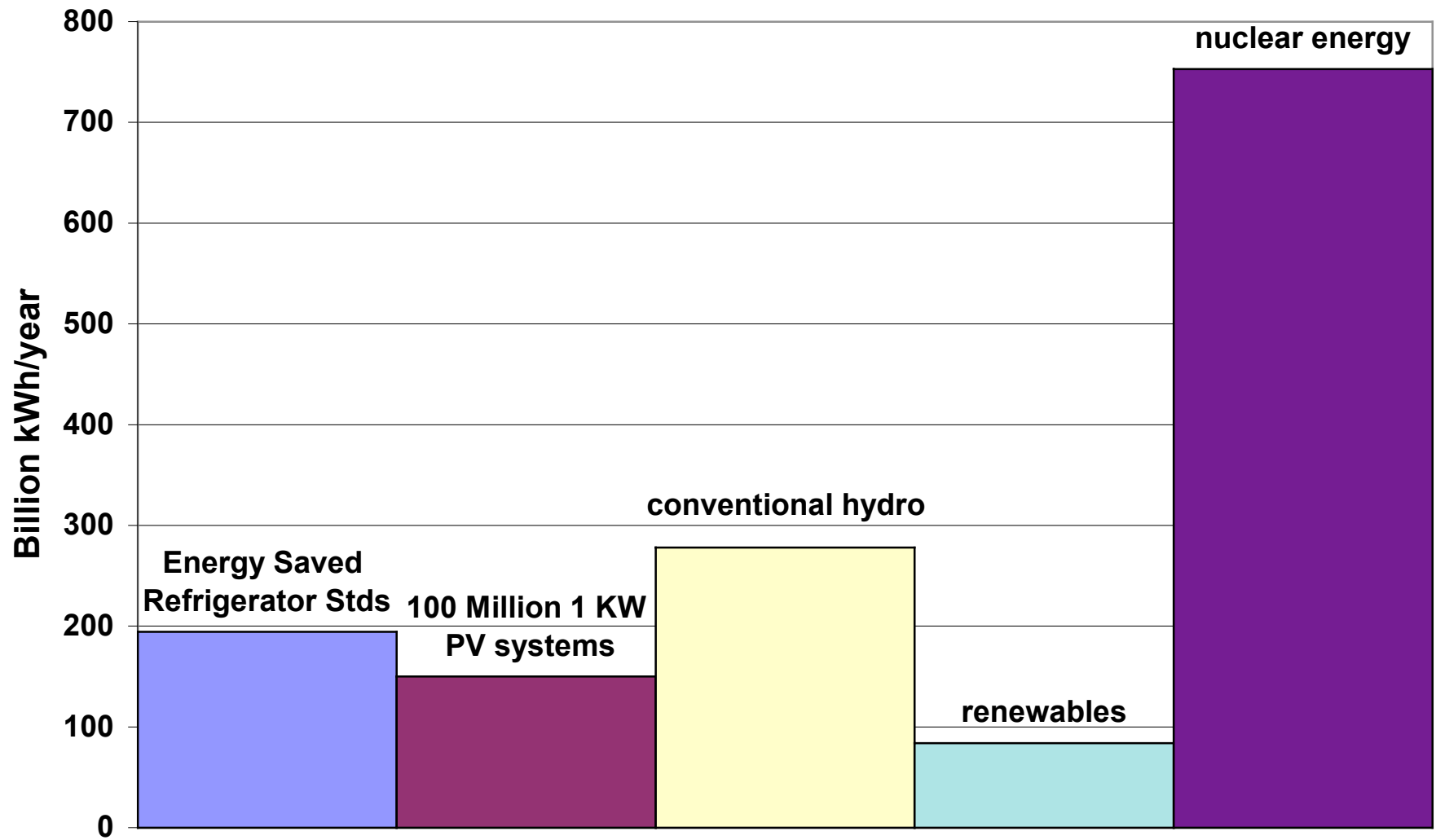


Source: David Goldstein

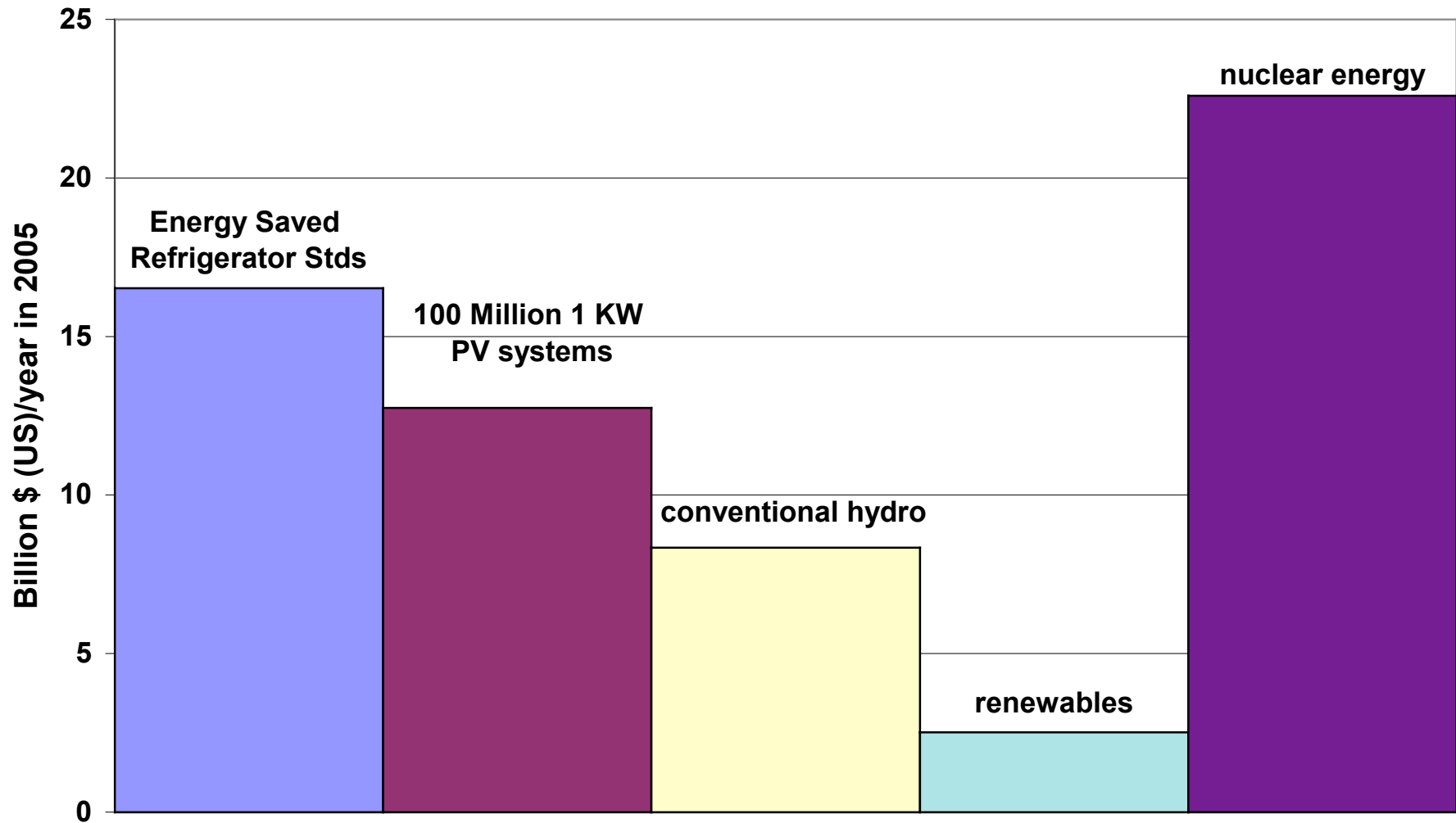
New Refrigerator Energy Use: 71% will be saved when stock completely turns over to 2001 Standards



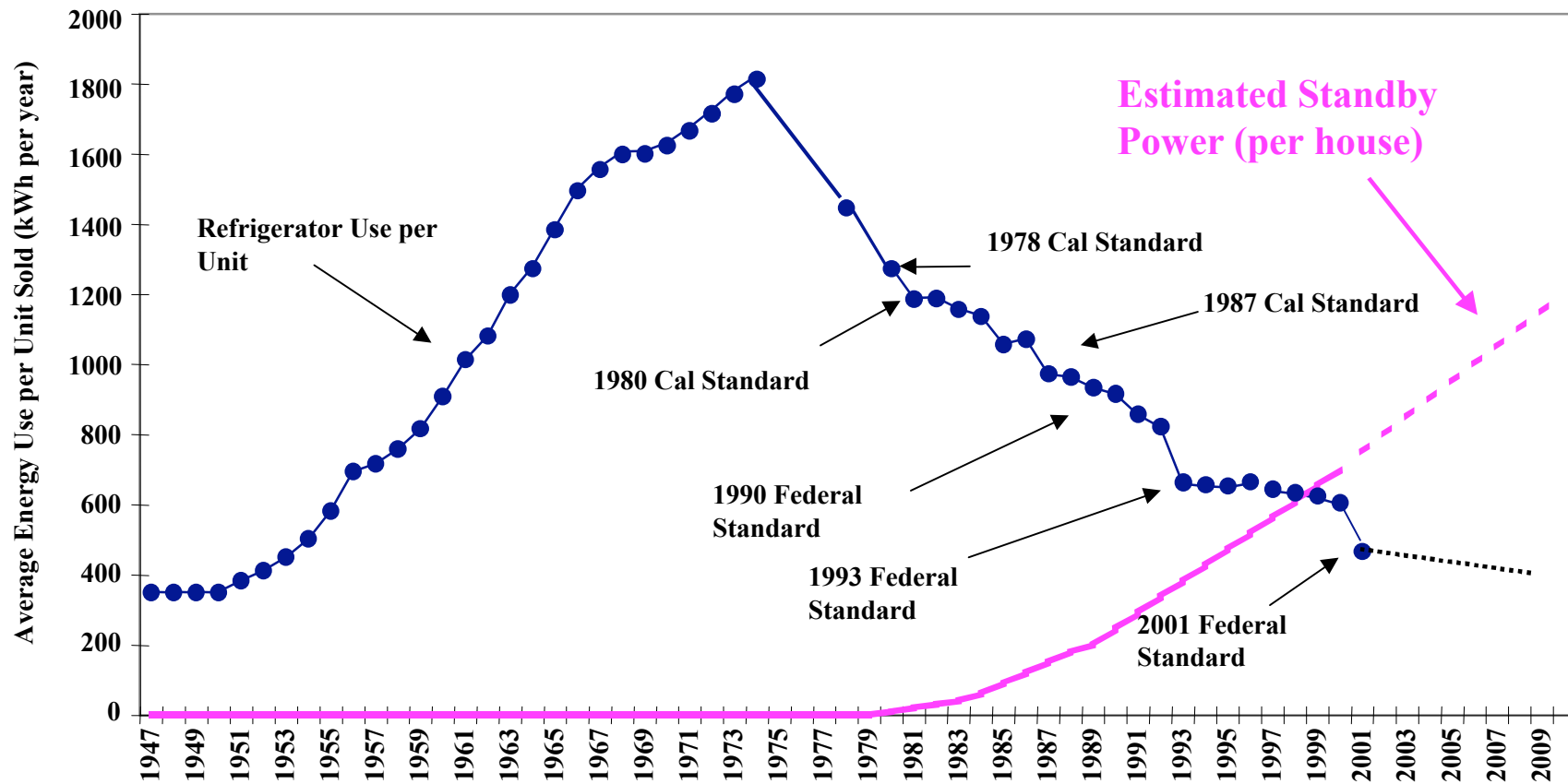
Annual Energy Saved vs. Several Sources of Supply



**Value of Energy to be Saved (at 8.5 cents/kWh, retail price) vs.
Several Sources of Supply in 2005 (at 3 cents/kWh, wholesale price)**

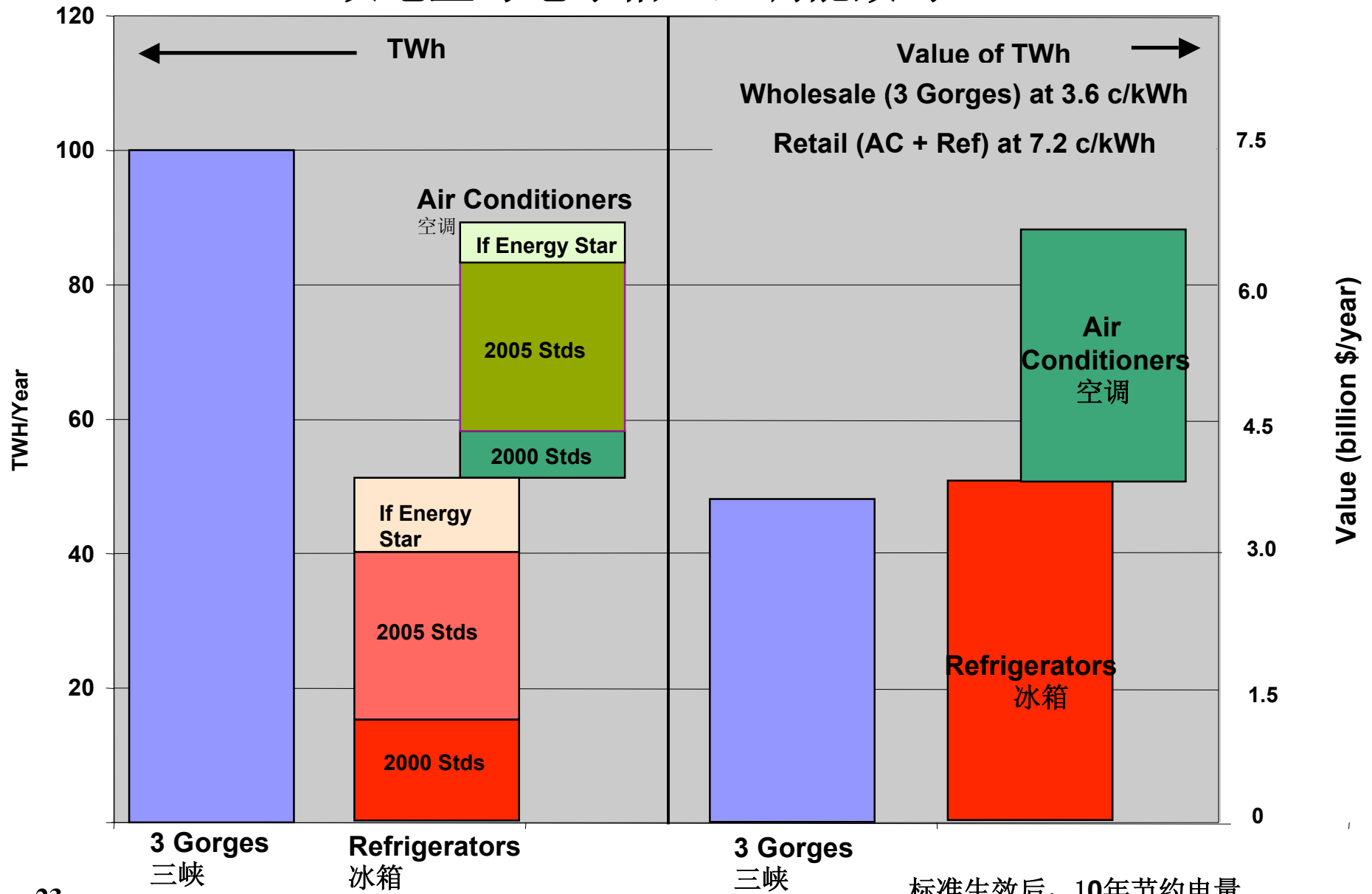


United States Refrigerator Use, repeated, to compare with Estimated Household Standby Use v. Time



Comparison of 3 Gorges to Refrigerator and AC Efficiency Improvements

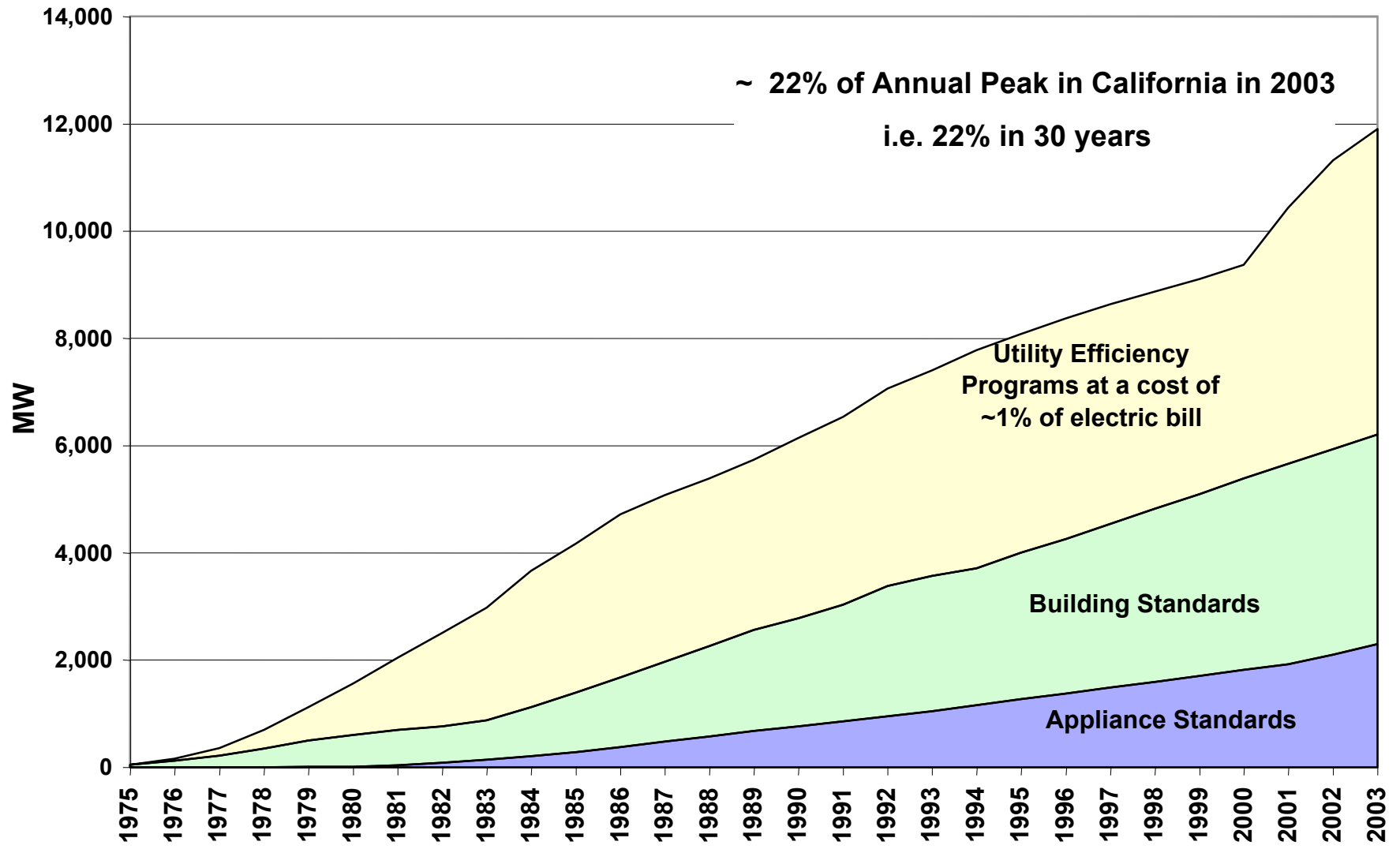
三峡电量与电冰箱、空调能效对比



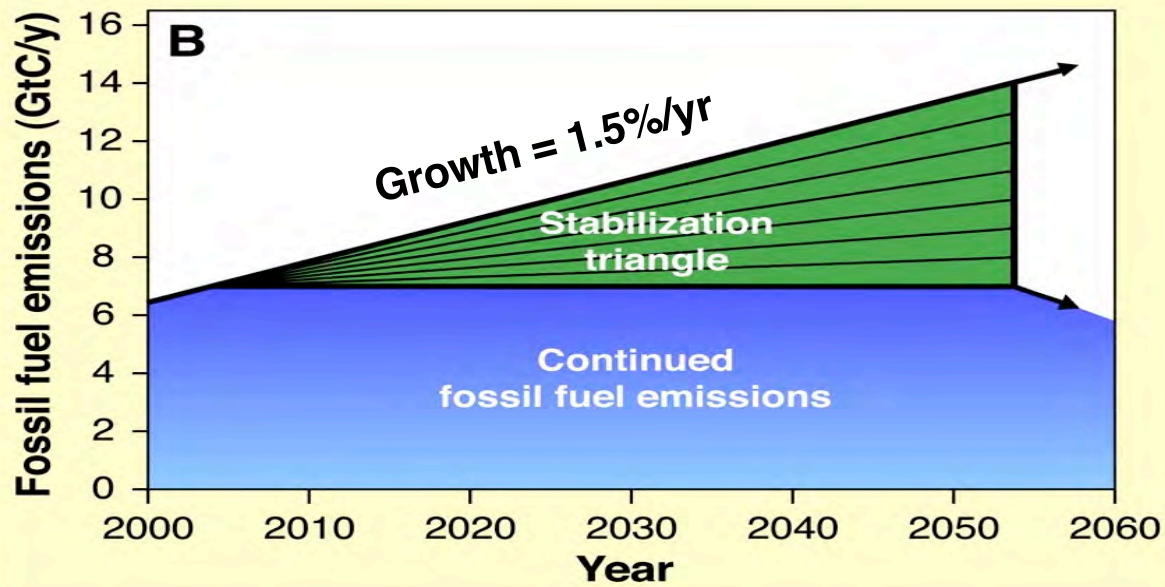
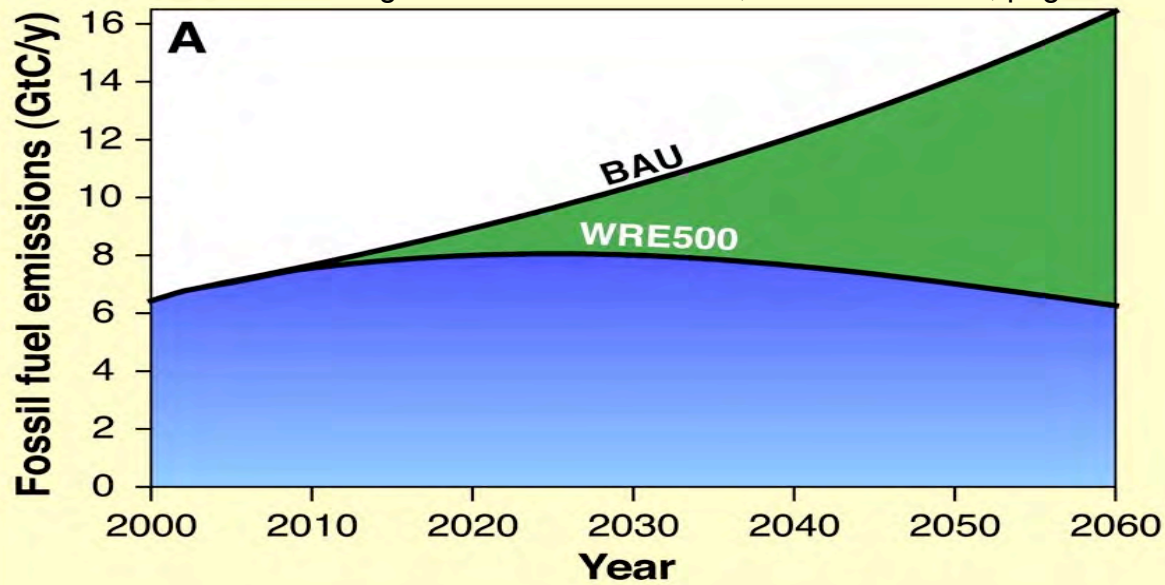
Savings calculated 10 years after standard takes effect. Calculations provided by David Fridley, LBNL

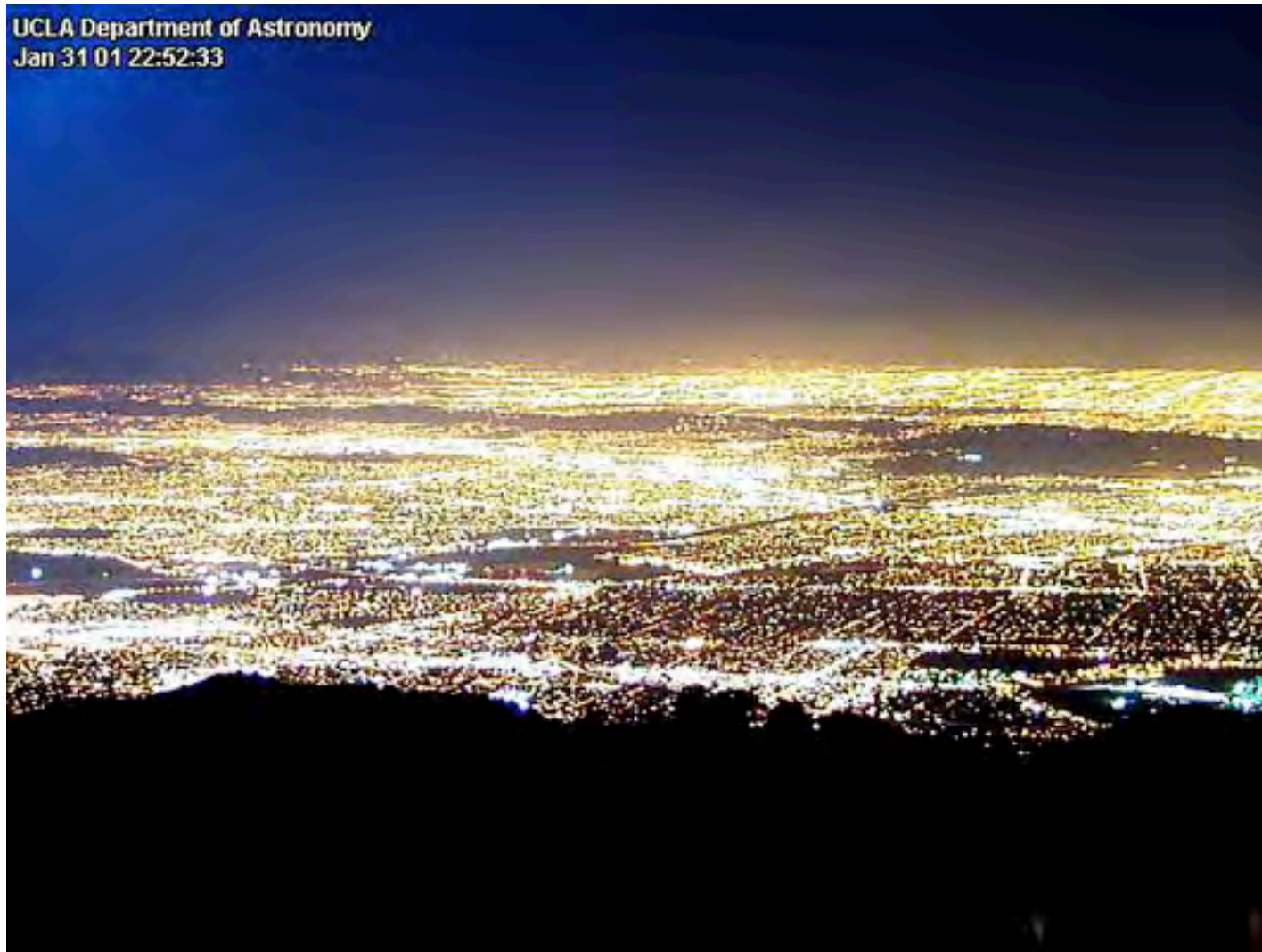
标准生效后, 10年节约电量

Annual Peak Savings from Efficiency Programs and Standards



Source: Stabilization Wedges: Pacala and Socolow, Science Vol 305, page 968

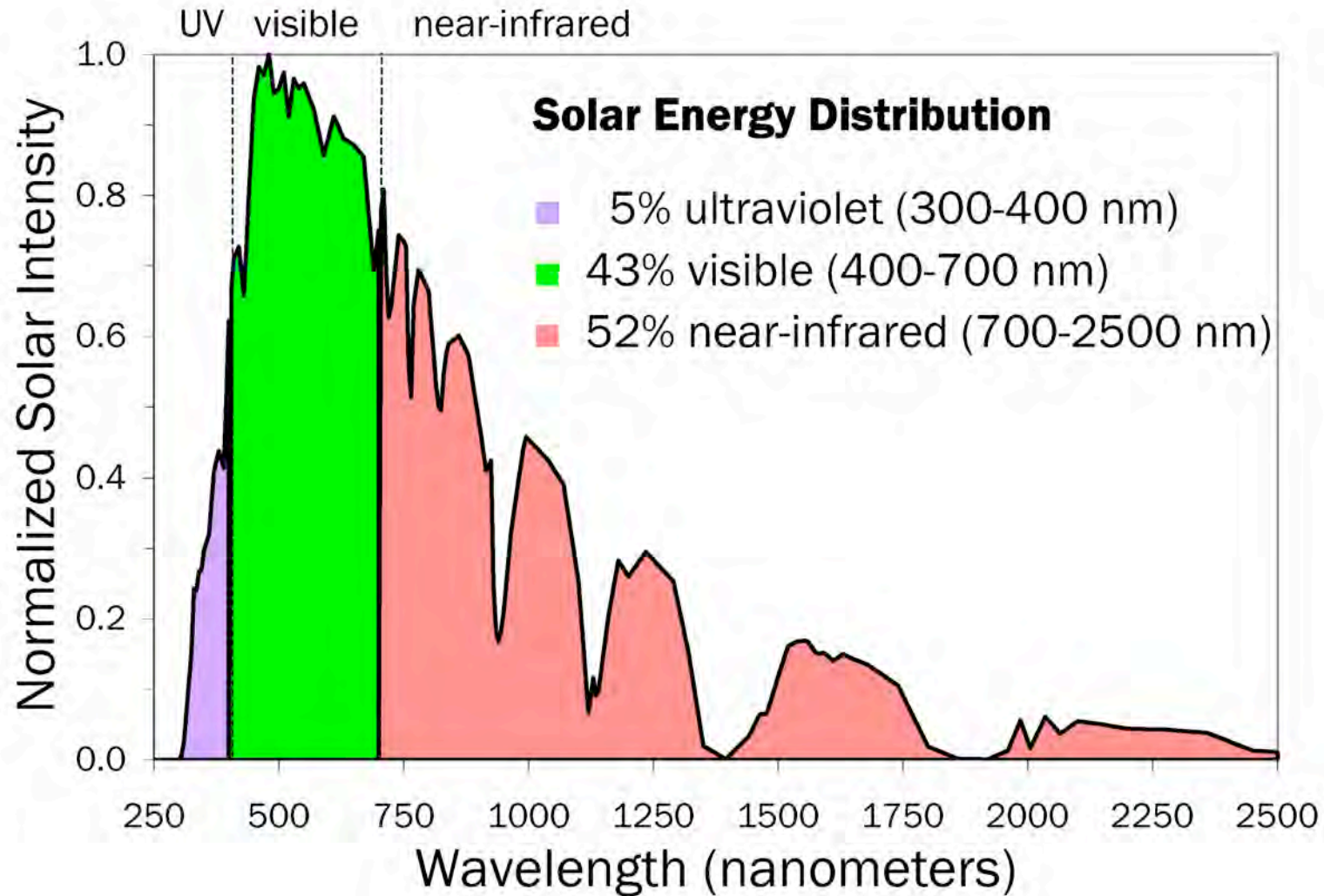




Illuminating Space vs. the Street



Cool Colors Reflect Invisible Near-Infrared Sunlight

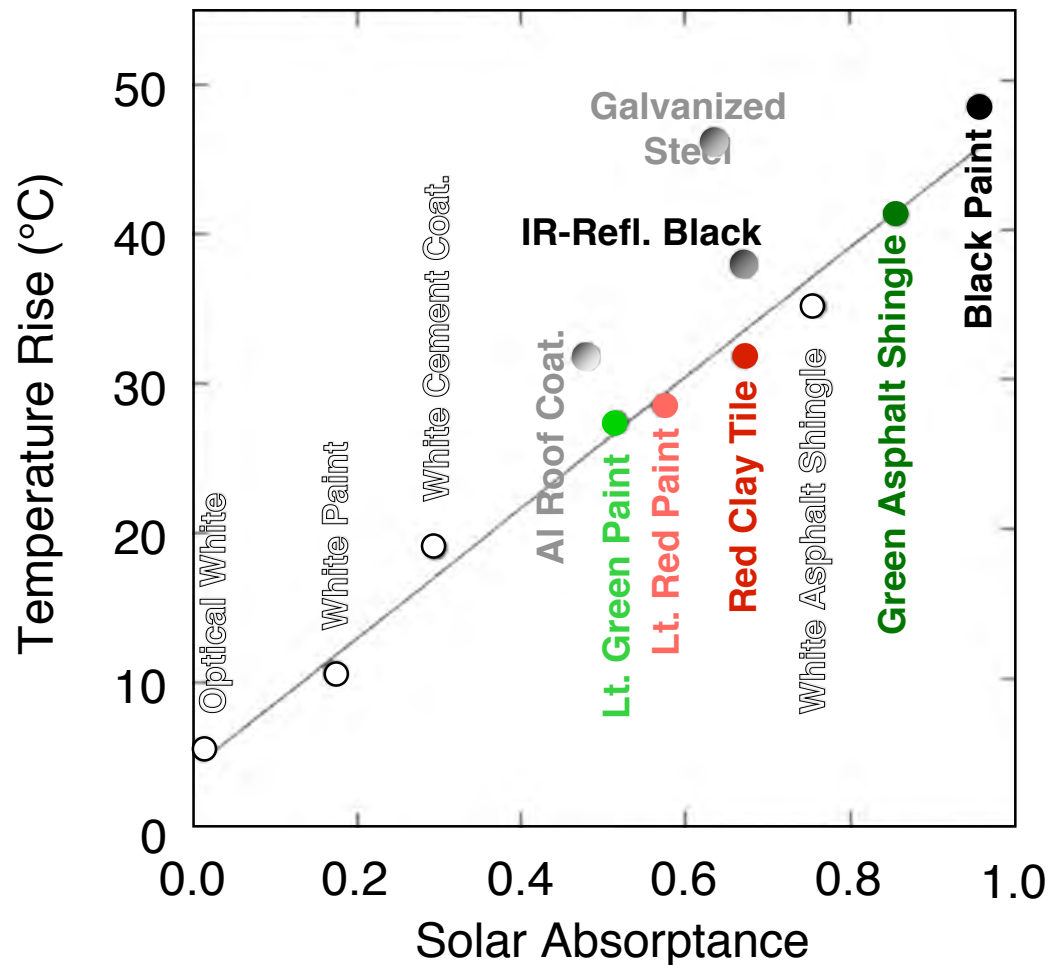


Heat Mirror Windows – Steve Selkowitz, LBNL

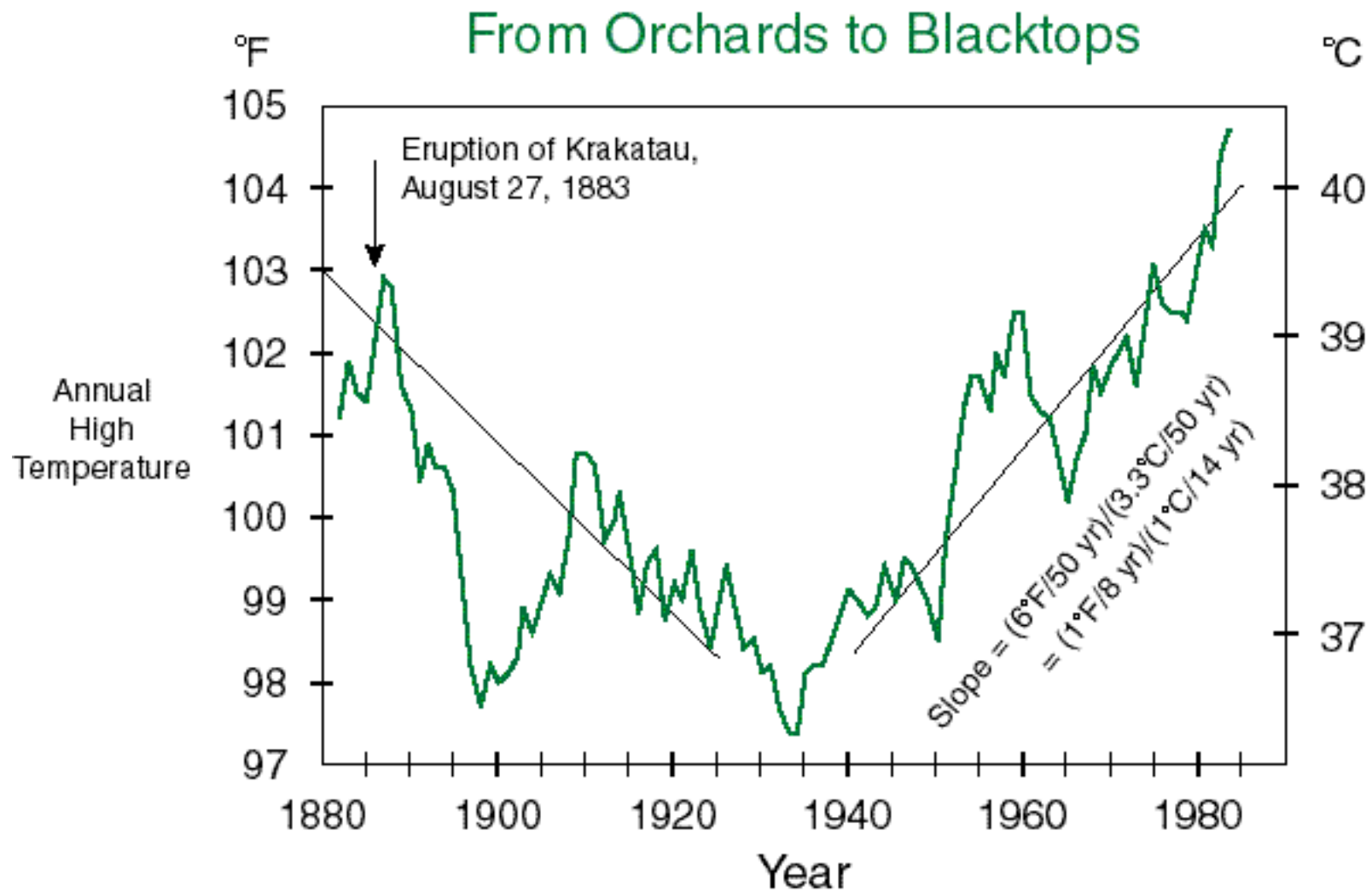
- ◆ Low Emissivity films are required by building standards world-wide. They reflect far infrared radiation. Retain indoor heat in winter, reflect outdoor heat in summer. They double the R-value of double glazing, and the inside pane is warm to the touch – more comfortable
- ◆ Before low-E, windows were 30% of the heat load of a home – now 15%.
- ◆ During a Montana winter, a north-facing low-E window, facing a snowy sunlit slope, is a net energy gainer.
- ◆ “Selective film are required for Commercial Buildings in California. They reflect far- and near-infrared radiation, and halve the solar gain through windows; including car windshields in BMW’s etc.
- ◆ Modern windows save ~1 Mbod of oil equivalent, = Alaskan oil.

Temperature Rise of Various Materials in Sunlight

Dr. Hashem Akbari, LBL Heat Island Group



Temperature Trends in Downtown Los Angeles

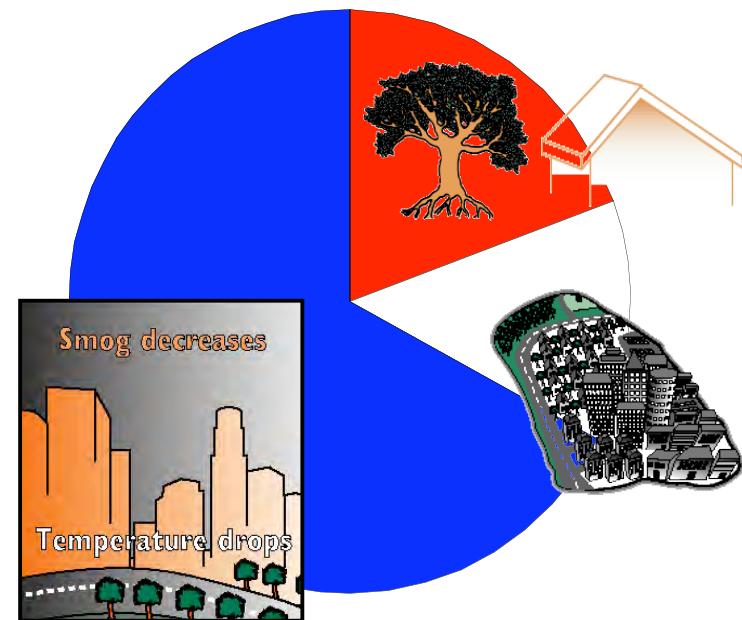


Potential Savings in LA

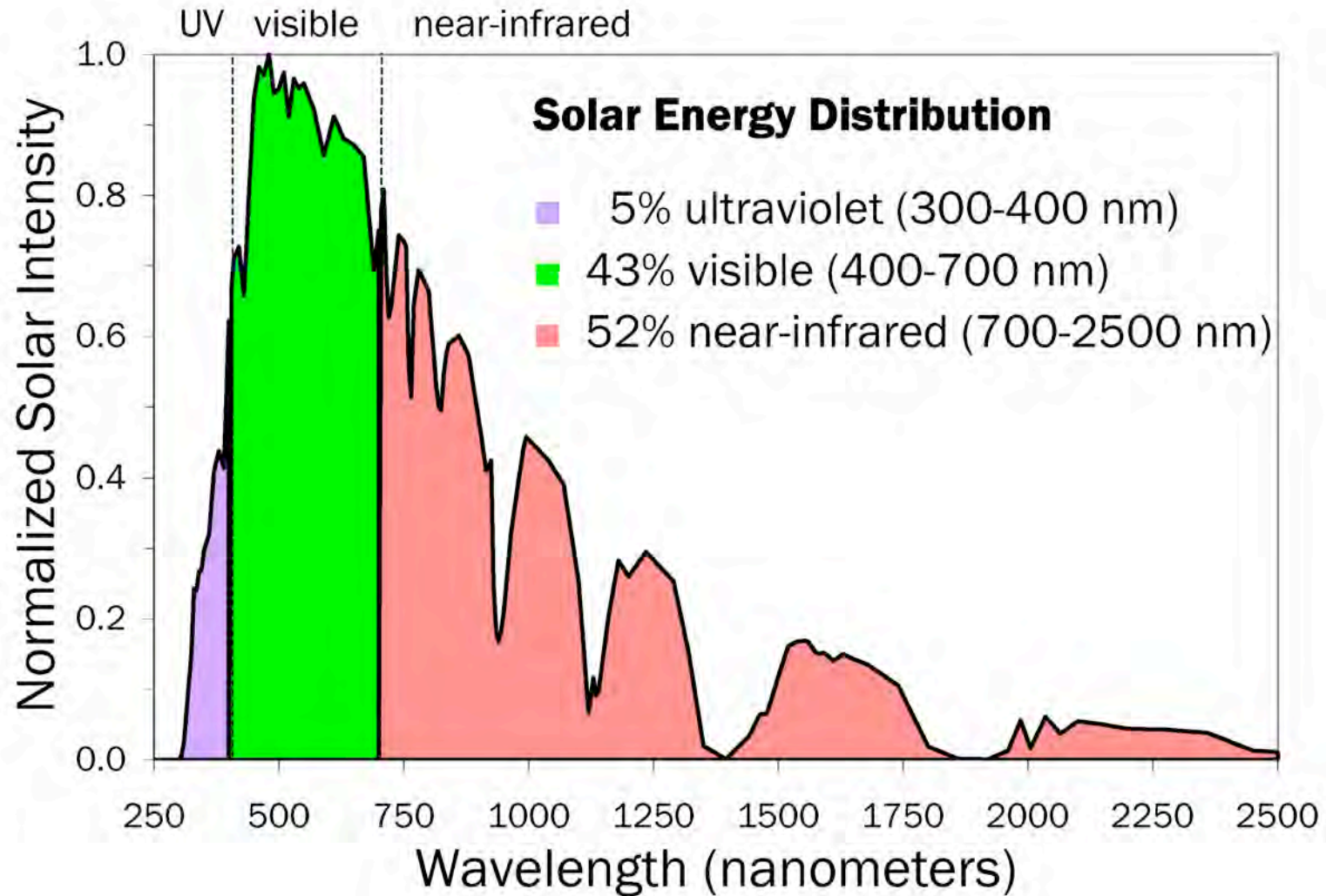
◆ Savings for Los Angeles

- Direct, \$200M/year
- Indirect, \$140M/year
- Smog, \$360M/year

◆ Estimate of national savings: \$10B/year



Cool Colors Reflect Invisible Near-Infrared Sunlight

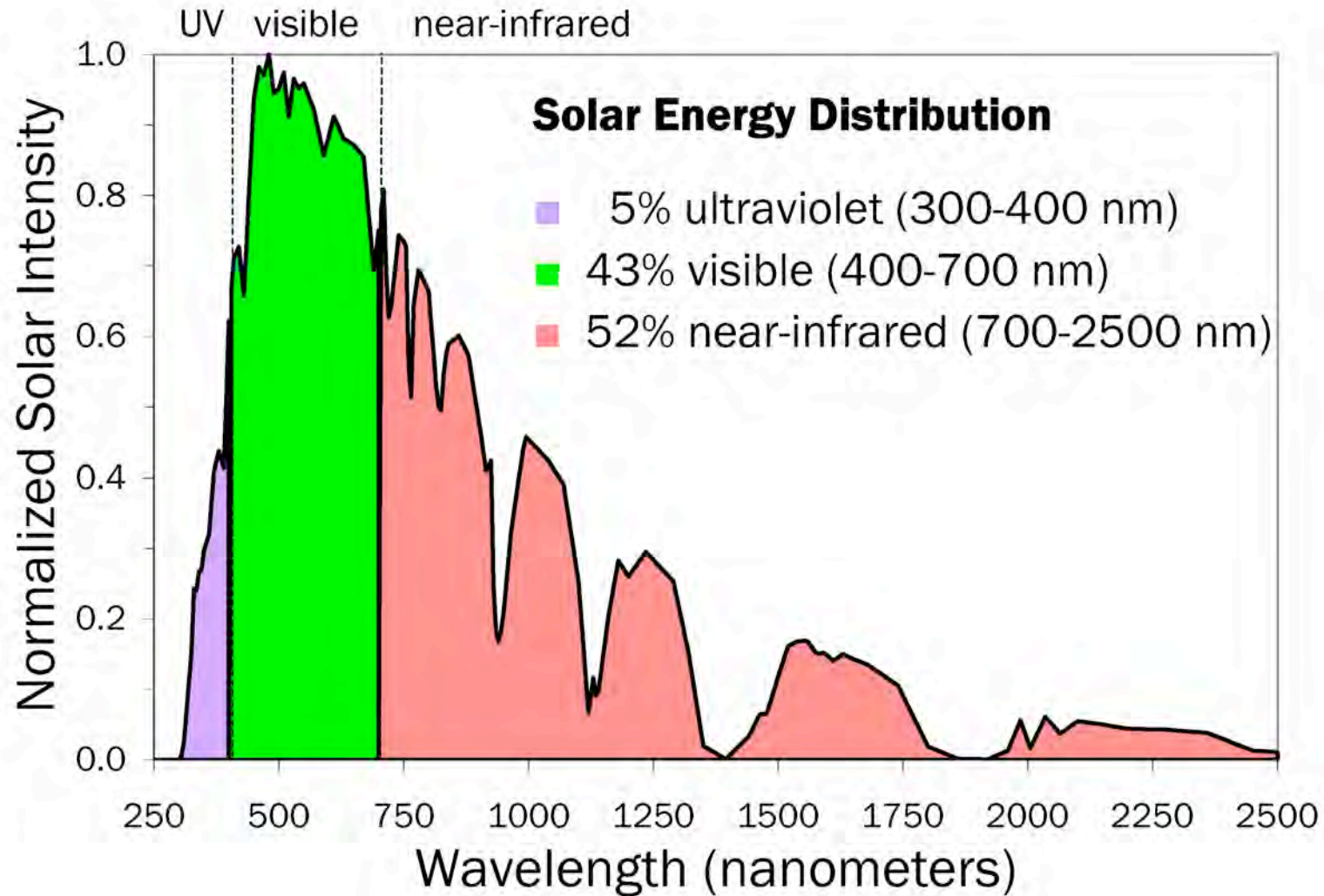


From Cool Color Roofs to Cool Color Cars

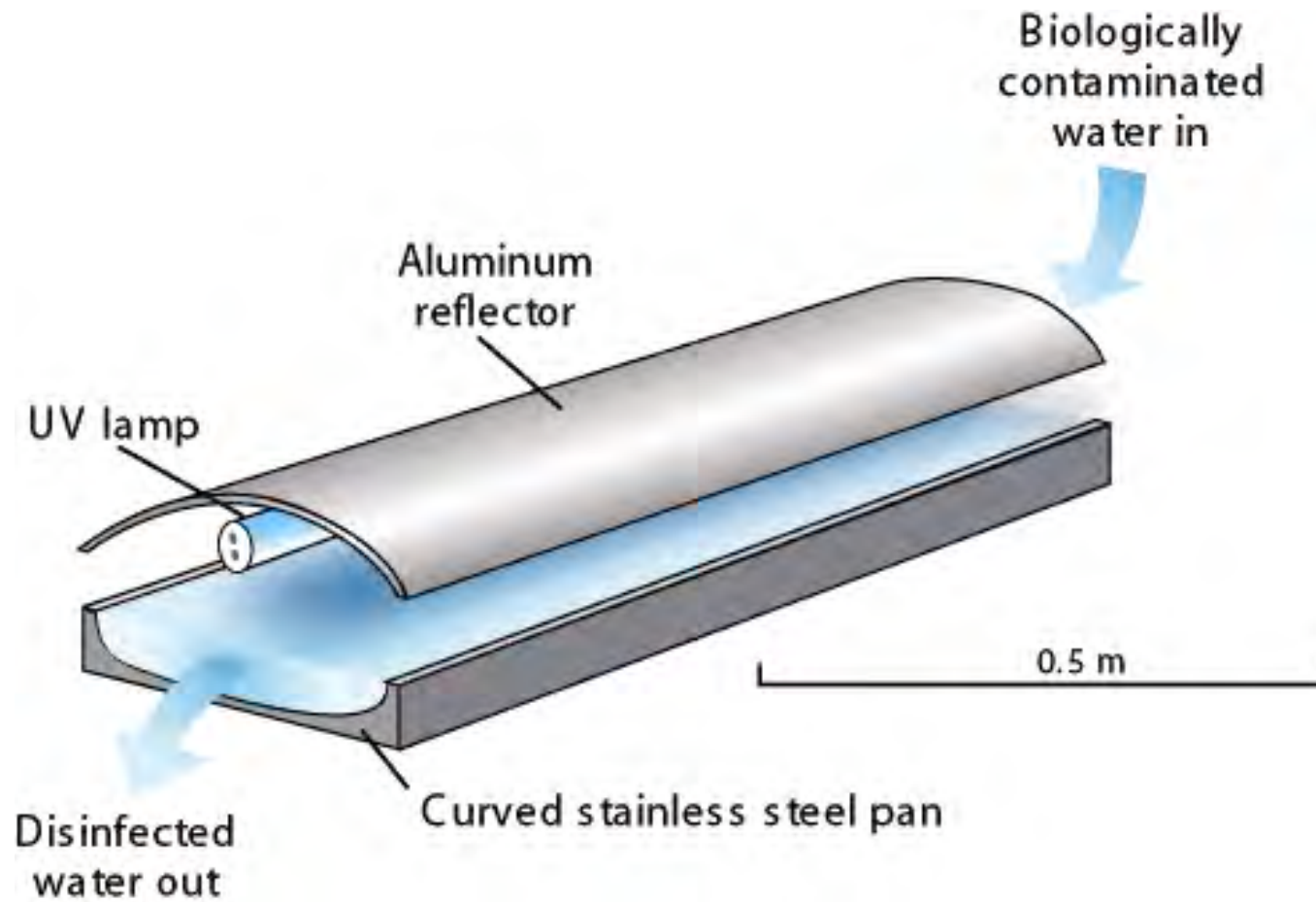


- ◆ Toyota experiment (surface temperature 10K cooler)
- ◆ Ford is also working on the technology

Cool Colors Reflect Invisible Near-Infrared Sunlight



UV Water Purification



Ultra Violet Water Purification for Villages in Developing World

Ashok Gadgil at LBNL points out if UV treatment replaces boiling 10 tons of water per day, each system avoids 4 tons of CO₂ per day. An American car emits only 4 tons of CO₂ per YEAR.

- ◆ Meet / exceed WHO and US EPA criteria
- ◆ Energy efficient: 60 watts disinfects 1 ton / hour
- ◆ Low cost: 4 cents disinfects a ton of water
- ◆ Reliable, Mature components
- ◆ Can treat un-pressurized water
- ◆ Rapid throughput: 12 seconds
- ◆ Low maintenance: once every three months
- ◆ >100 units now operating in India and Phillipines
- ◆ <http://www.waterhealth.com/>

Dr. Ashok Gadgil's Darfur Cookstove Project

In Nov.-Dec. 2005, he visited Darfur camps, and showed that with a \$10 metal stove, and training to use it, only half the fuelwood is needed.

The stove saves fuelwood worth \$160 annually for a refugee family

Since that time, Ashok Gadgil has improved stove efficiency by another factor of two

<http://www.osti.gov/bridge/servlets/purl/878538-hMpQn3/878538.PDF>

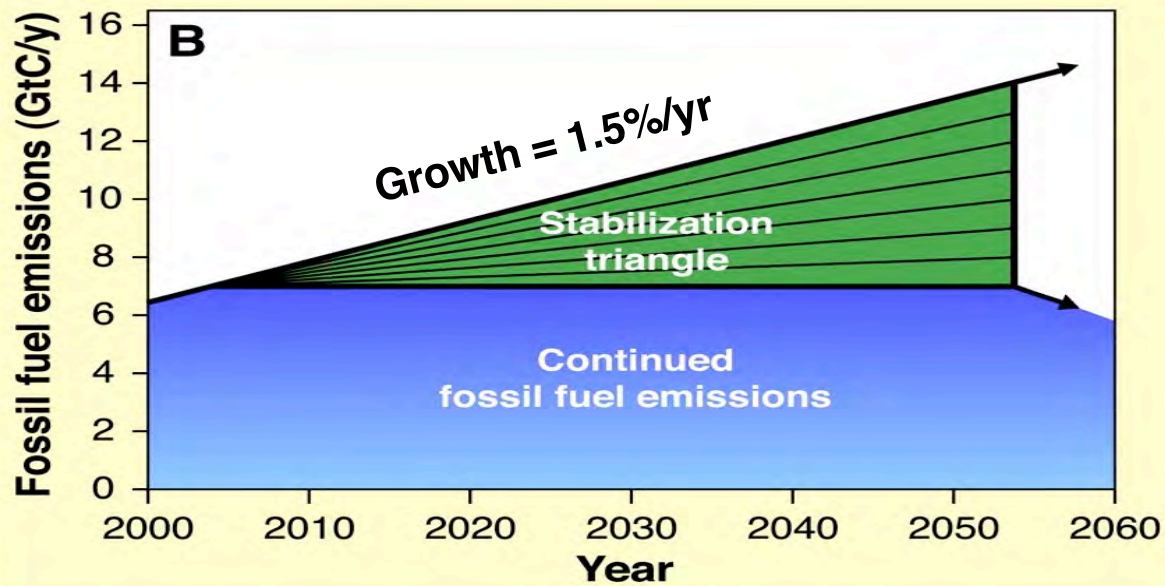
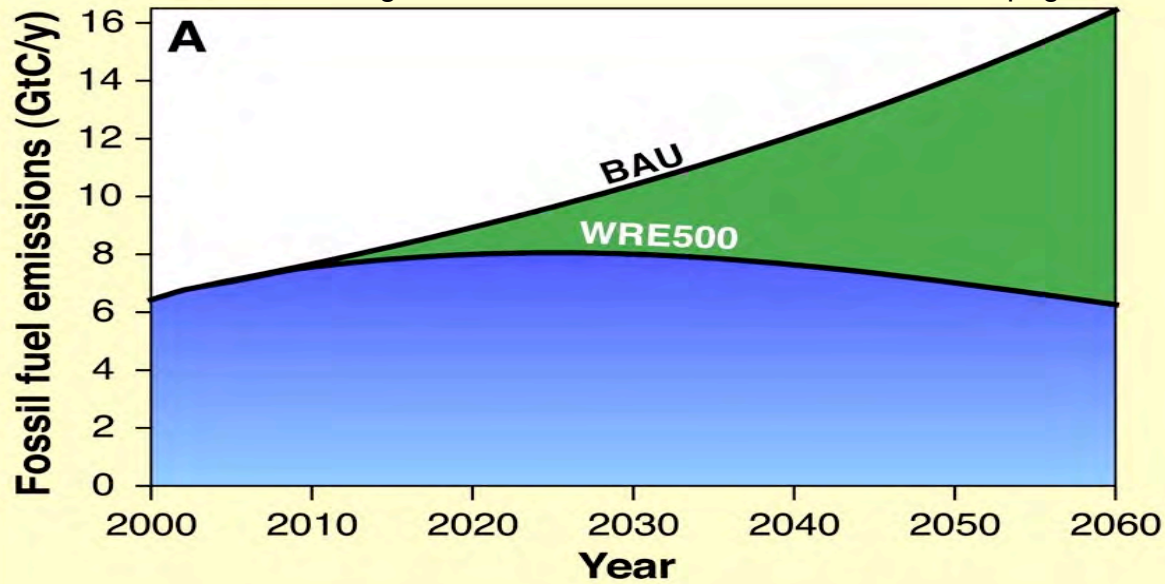




LEDs Powered with Photovoltaics

- ◆ Evan Mills at LBNL points out the following: If 1 billion people could replace kerosene lamps with LEDs, emissions would drop by the equivalent of 1.3 million barrels of petroleum per day
- ◆ http://eetd.lbl.gov/emills/PUBS/Fuel_Based_Lighting.html

Source: Stabilization Wedges: Pacala and Socolow, Science Vol 305, page 968



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